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APR 80 M HOLTZ, W SWANSEEN, M KARLIN

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DISCRETE ADDRESS BEACON SYSTEM (DABS) BASELINE TEST AND EVALUATION

LEVEL II

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Atlantic City, New Jersey 08405

INTERIM REPORT

APRIL 1980

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16. Abstract

Tests and evaluation (T&E) were conducted principally to determine baseline performance characteristics of the Discrete Address Beacon System (DABS) sensor employing the software and associated parameter values as delivered by Texas Instruments (TI), Incorporated in June 1979. A secondary objective was to highlight those areas where changes in system parameters, made necessary by the maturing of the DABS/Automatic Traffic Advisory and Resolution Service (ATARS) system concept, would require further study and test prior to issuance of the Technical Data Package (TDP). Simulation techniques, targets of opportunity, and DABS transponder-equipped aircraft were used.

The DABS sensor test program was accomplished with an Air Traffic Control Radar Beacon System (ATCRBS) 5-foot antenna having a 2.4° beam width, and the DABS sensor transmitter power output and effective beam width values as delivered by the contractor. In order to satisfy a recent airway facility implementation requirement, this antenna was used instead of the 4° beam width antenna for which the sensor parameters were originally designed. This may have led to less than optimum system integration. However, DABS was found to meet or exceed the majority of its requirements with the narrower beam width.

Data reduction and analysis tools developed by the National Aviation Facilities Experimental Center (NAFEC) were used to determine sensor performance characteristics and to highlight areas for further analysis.

The characteristics evaluated include: surveillance, failure/recovery, communication, reliability, sensor/air traffic control (ATC) interface, and DABS/Automatic Radar Terminal System (ARTS) III performance comparison.

It was concluded that, with few exceptions, the DABS engineering model in the implementation tested performed in compliance with or exceeded the requirements as defined in the DABS Engineering Requirements (FAA-ER-240-26). Those exceptions are discussed in the body of the report along with recommendations for further activities.

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METRIC CONVERSION FACTORS

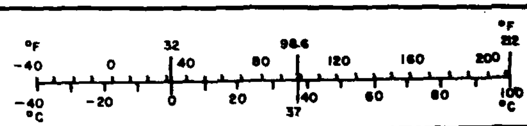
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

The Discrete Address Beacon System (DABS) has been designed as an evolutionary replacement for the Air Traffic Control Radar Beacon System (ATCRBS), and to provide the enhanced surveillance, Automatic Traffic Advisory and Resolution Service (ATARS) and communications capabilities required for air traffic control (ATC) in the 1980's and 1990's. Compatibility with ATCRBS has been emphasized to permit an extended and economical transition.

The requirement for the development of DABS was identified in the 1969 Department of Transportation Air Traffic Control Advisory Committee (ATCAC) Study. The first phase of DABS development consisted of a feasibility study and validation of the DABS concept. This study was conducted by the Massachusetts Institute of Technology (MIT) Lincoln Laboratory. After successfully demonstrating the feasibility of the DABS concept, engineering requirments (ER's) were prepared by Lincoln Laboratory for the development of three single-channel DABS sensors which could operate as a network and interface with terminal ATC facilities.

Texas Instruments (TI), Incorporated was awarded a contract to fabricate the three engineering laboratory models of the DABS sensor. After completing factory acceptance tests, the sensors were delivered to the National Aviation Facilities Experimental Center (NAFEC), and Clementon and Elwood, New Jersey, where they were installed and subjected to field acceptance tests. Upon completion of the field acceptance tests, NAFEC engineers conducted system baseline tests on the terminal configured NAFEC sensor.

There were two principal objectives of the activity: (1) to determine the baseline performance characteristics of the DABS sensor employing the software and associated parameter values as delivered; and (2) to highlight those areas where changes in system parameters, due to the continual maturing of the DABS/ATARS concept, would require further study and test prior to issuance of the Technical Data Package (TDP). Simulated target replies at the intermediate frequency (IF), targets of opportunity, and controlled test aircraft were all used in the test and evaluation (T&E).

Problems which were observed during system tests are identified and corrections are proposed, where warranted. The impacts of these corrections on the specification for the production system are discussed. Where feasible, changes will be incorporated into the present system and tested during the next phase of DABS performance testing. The results will be used to finalize the requirements for the production system.

The sensor functions evaluated include: (1) surveillance, (2) failure/recovery, (3) communications testing, (4) reliability, (5) sensor-to-ATC interface, and (6) a comparison of DABS sensor/Automatic Radar Terminal System (ARTS) III performance for target reports. The simulation surveillance and communication tests were conducted with nominal target, worst-case target, and fruit environments.

Analysis of data collected was expedited by development and use of automated analysis programs that provided measures of performance and data plots for large samples of data. The primary program compared the simulated DABS and ATCRBS inputs, as generated by the Aircraft Reply and Interference Environmental Simulator (ARIES), to the samples of data extracted on magnetic tape from the sensor. The results are presented primarily in graphic form and demonstrate sensor performance relative to input variables. The test areas involving targets of opportunity and/or controlled test aircraft were DABS sensor/ARTS III comparison.

It was concluded that the DABS engineering sensor in a terminal configuration, as implemented by TI and tested to date, complied with or exceeded the requirements specified in the DABS ER (FAA-ER-240-26), except for a few areas which are discussed in the SUMMARY OF RESULTS section. The results of the DABS performance test and evaluation showed improved report reliability and a highly reliable air-ground communications link.

The sensor test program was accomplished with the ATCRBS 5-foot antenna having a 2.4° beam width, and the DABS sensor transmitter power output and effective beam width values as delivered by the contractor. It was used in lieu of the 4° beam width antenna for which the sensor parameters were originally designed in order to satisfy a recent airways facilities implementation requirement for a narrower beam. The transmitter output power was not adjusted to compensate for the differences in gain between the 2.4° and 4° beacon antenna. This may have led to less than the optimum system integration. However, a majority of the DABS requirements were met or exceeded. It is our opinion that increasing the transmitter output power and the effective beam width would further enhance performance in the areas of altitude reliability, ATCRBS probability of detection (P_d), communications delivery, and possibly short term peak capacity. These effects are now being studied. In addition, an investigation is being made into the feasibility of "tailoring the system" in accordance with the transmitting/receiving antenna with which it is implemented, and any other external system components.

Many of the terms used to describe the results, recommendations, and conclusions of the testing have specific application and meaning to the DABS and to surveillance performance testing. These terms have been used and defined in other sections of this report and have been repeated here to facilitate an understanding of the conclusions and recommendations.

NON-NETTED. A single DABS sensor having responsibility for total surveillance coverage without DABS sensor-to-sensor communication.

SENSOR CAPACITY. The ER requires the sensor to be capable of processing:

1. A total of 400 aircraft.

2. A minimum short term peak capacity of 12 aircraft in a 1.0° azimuth wedge for up to four continuous wedges.

3. A peak capacity of 50 aircraft uniformly distributed in an 11.25° sector for not more than eight consecutive sectors.

FRUIT. Aircraft replies which are nonsynchronous to the system under test and result from replies to interrogations from adjacent interrogators.

FRUIT RATES. Three ATCRBS and three DABS fruit rates were selected for baseline simulation tests. The ATCRBS fruit rates were selected to be 0, 4,000, and 44,000 per second. The 4,000 per second rate simulates a nominal fruit environment encountered in areas such as New York City or Los Angeles. The 44,000 per second rate was chosen to generate eight main beam fruit per sweep within the 60-nmi range of a terminal facility in accordance with the FAA-ER-240-26 capacity requirement. Two DABS fruit rates were chosen: 50 replies per second, which was selected as a nominal value; and 200 replies per second, which was considered to be a worst-case situation.

BEACON ROUND RELIABILITY (R/R). The percentage of replies received from an aircraft compared to the number of interrogations directed to the aircraft (reply probability). The values of 0.93 and 0.70 were chosen. An R/R of 0.93 is representative of the value presently encountered. A 0.70 R/R was chosen because it represents the worst-case experienced to date with ATCRBS.

PROBABILITY OF DETECTION (P_d). The number of scans in which a target report for any given aircraft is provided by the DABS sensor, divided by the total number of elapsed scans over which the P_d is being measured.

BLIP SCAN RATIO (b/s). The number of times the surveillance file for a track is updated, divided by the sum of the number of updates, plus the number of coasts. A track update may be from beacon data or radar data.

$$b/s = \frac{\text{No. of updates}}{\text{No. of updates + No. of coasts}}$$

IDENTITY CODE (ID) RELIABILITY. The number of times a target with the correct mode A-code was detected, divided by the total number of times the target was detected.

$$\text{ID Reliability} = \frac{\text{No. of targets detected with the correct mode A-code}}{\text{Total No. of times target detected with correct or incorrect code}}$$

In a similar manner

$$\text{Altitude Reliability} = \frac{\text{No. of targets detected with correct mode C-code and all high-confidence bits set}}{\text{Total No. of times target detected with correct or incorrect codes}}$$

$$\text{DABS ID Reliability} = \frac{\text{No. of targets detected with correct DABS ID}}{\text{Total No. of times target detected}}$$

FAILURE/RECOVERY TEST. A sensor failure (i.e., power, memory, computer voting, or modem) was induced at a predetermined time and sensor performance was recorded. The time until the sensor reestablished discrete interrogations and resumed target tracking (DABS and ATCRBS) was measured.

ATCRBS/DABS ALL-CALL INTERROGATIONS. These interrogations solicit responses from both DABS and ATCRBS transponder-equipped aircraft. The ATCRBS equipped aircraft respond with a normal reply while the DABS transponder-equipped aircraft respond with an All-Call message containing a unique aircraft address.

DABS ROLLCALL INTERROGATIONS. Discrete interrogations which contain a unique address field that is decoded by the DABS transponder-equipped aircraft having the unique address and being tracked by the DABS sensor.

ZENITH CONE. Volume of airspace having elevation angles greater than 30° above the DABS sensor antenna.

CONFLICTING TARGETS. Two or more targets that are within 2.5° and 2 nmi of each other.

COMMUNICATIONS TESTING (Comm A/B). This testing verified the operation of the DABS communications software as well as the transaction processing between the DABS sensor and simulated aircraft.

The Comm A message delivers information from the ground station to the aircraft and may elicit a Comm B response from the aircraft.

BEAM WIDTH. The width of a radar beam measured between lines of half-power intensity.

EFFECTIVE BEAM WIDTH. The receive beam width as defined by the received side lobe suppression (RSLS) signals, and over which the DABS and ATCRBS processor functions are performed. Replies outside of this effective beam width are disregarded. For the baseline T&E effort the effective beam width was 2.3°.

Several of the key results and recommendations are delineated below, it should be reiterated that these results were obtained with parameter values as delivered by the contractor.

RESULTS

1. The P_d of either ATCRBS or DABS targets was greater than 98 percent for a nominal R/R and fruit rate.

2. The ID reliability and altitude reliability for DABS roll-call aircraft were always 100 percent.

3. The mode A-code reliability for ATCRBS targets was generally 100 percent and always greater than 98 percent. The ATCRBS altitude reliability, under conditions of high fruit rates (44,000 per second) or conflicting targets, was reduced from 98 to 89 percent.

4. The average number of DABS interrogations per scan per target was 1.2. The number of DABS interrogations for targets transitioning through the zenith cone ranged from 100 to 180 depending on aircraft altitude.

5. ATCRBS and DABS processing as specified for short-term capacity in the ER was not achieved. A portion of the problem could be attributable to the reduction in antenna beam width from the original design of the sensor. This is still under investigation. Other system improvements are also being evaluated in light of changing requirements.

6. The DABS sensor recovered from all single computers and most ensemble failures within one or two scans after the occurrence of the failure. Modem and memory failures were handled by the sensor with no degradation in sensor performance.

7. The major problems encountered in the sensor-to-ATC interface tests were due to deficiencies with the version of the Common International Civil Aviation Organization (ICAO) Data Interchange Network (CIDIN) protocol used in the DABS engineering model.

8. All Comm A/B messages were delivered during the testing. In 10 percent of the cases for which three transactions per aircraft were attempted in a single scan, a second scan was required to complete the transaction.

9. The mean time between failures (MTBF) of the engineering model (not including the antenna and the air conditioner) is estimated to be 770 hours, assuming that preventive maintenance is performed once each month (720 hours). This estimate is based on 9 months of accumulated failure data. The predicted MTBF was 781 hours.

RECOMMENDATIONS

1. The short-term capacity values specified in the ER should be reevaluated prior to undertaking any capacity improvement modifications of the engineering model.

2. The DABS channel management software, as implemented in the DABS sensor, should be modified to permit rescheduling of roll-calls within a DABS period and to better support ATARS. It is expected that a more efficient implementation of the channel management function would also increase the sensor capacity.

3. DABS targets should be dropped upon entering the zenith cone for a non-netted system so as to suppress unnecessary interrogations.

4. The DABS sensor specified for production should include redundant elements for the transmitter, receiver, and processor to meet the 20,000-hour MTBF requirements.

5. A complete description of the failure/recovery requirements should be included in the DABS production specifications. This document should consider a distributive processing architecture in support of failure/recovery which provides for full flexibility of computers and ensembles.

6. An investigation should be conducted to ensure that proposed modifications to the CIDIN protocol will resolve the deficiencies noted in the version implemented in the DABS engineering model.

INTRODUCTION

PURPOSE.

The purpose of this test and evaluation (T&E) activity was to baseline the performance characteristics of the Discrete Address Beacon System (DABS) sensor using simulated target reply inputs at the intermediate frequency (IF) level, targets of opportunity, and controlled test aircraft. The results reported herein are the results of testing the DABS performance system employing the configuration and adaptation parameter values provided by the contractor at the time the system was turned over to the Federal Aviation Administration (FAA) for testing.

When possible, the cause of any anomalies observed during system tests have been identified. Where anomalies appear to warrant a change in the specification of a production system, recommendations are provided. If feasible, changes to correct anomalies by resolution of implementation errors are proposed.

If the recommended changes are of the level that can be incorporated into the present system, they will be implemented and tested during the next phase of DABS performance testing.

BACKGROUND.

In 1968, the Department of Transportation Air Traffic Control Advisory Committee (ATCAC) was formed for the purpose of recommending an air traffic control (ATC) system which would meet the requirements of the 1980's and beyond. In 1969, the ATCAC published its report which contained numerous recommendations for ATC system development. These recommendations have become the basis of what is frequently called the Upgraded Third Generation ATC System. A major committee recommendation was to upgrade the Air Traffic Control Radar Beacon System (ATCRBS) to incorporate data link and discrete address capabilities for support of ATC automation. The committee also recommended the development of a ground-based collision avoidance system which would, on the basis of information derived from the upgraded ATCRBS, provide advisory information and manuever instructions to aircraft on potential collision courses. The ground-based collision avoidance system was called Intermittent Positive Control (IPC), and subsequently renamed Automatic Traffic Advisory and Resolution Service (ATARS).

The Systems Research and Development Service (SRDS) was assigned the responsibility of developing a system which would provide improved surveillance and ground-air-ground digital data link communications for support of ATC automation. The system was named DABS. SRDS selected the Massachusetts Institute of Technology (MIT) Lincoln Laboratory to perform concept validation and system definition. Beginning in 1972, Lincoln Laboratory established an experimental model of a DABS to support the pursuit of system validations and definitions. The model was called the Discrete Address Beacon System Experimental Facility (DABSEF). This effort culminated in the development of a comprehensive DABS engineering requirement (ER) which became the technical specification for the DABS engineering model sensors built by Texas Instruments (TI), Incorporated and delivered to three geographical locations within 30 nautical miles (nmi) of the National Aviation Facilities Experimental Center (NAFEC). There is a DABS sensor at the NAFEC airport surveillance radar (ASR-7) terminal radar site, the Elwood air route surveillance radar (ARSR-2) facility, and the newly established terminal facility (ASR-8) located at Clementon, New Jersey.

Prior to delivering the three sensors, an acceptance test program was conducted at the TI factory. The factory tests consisted of unit, subsystem, and system tests which were designed to demonstrate that the delivered sensors met the ER specified requirements. Unit tests were applicable to specific functional elements; e.g., receiver, transmitter, modulation control unit, or ATCRBS reply-to-reply processing. Subsystem tests were conducted with groups of related units collectively supporting a sensor function; e.g., the interrogator and processor, computer, and communications subsystems. System tests exercised the entire DABS sensor to the extent possible at the factory. In addition to the factory testing, the sensors were tested after installation at the field facilities to determine if performance was consistent with that achieved during factory testing.

After completion of the above test program, NAFEC was responsible for determining the DABS performance testing characteristics by implementing an in-depth test and evaluation program. This program is detailed in Report No. FAA-NA-79-151, "DABS Single Sensor Performance Test Plan."

The DABS sensor test program was accomplished with an ATCRBS 5-foot antenna having a 2.4° beam width, and the DABS sensor transmitter power output and effective beam width values as delivered by the contractor. In order to satisfy a recent airway facilities implementation requirement, this antenna was used instead of the 4° beam width antenna for which the sensor parameters were originally designed.

SYSTEM DESCRIPTION.

THEORY OF OPERATION, DISCRETE ADDRESS BEACON SYSTEM (DABS). The DABS is a cooperative surveillance and communications system for ATC. Each aircraft is assigned a discrete address or unique code which permits data link communications to or from a particular aircraft. The data link operates integrally with DABS surveillance interrogations and replies.

The DABS sensor has two modes of operation: ATCRBS mode and DABS mode. The sensor uses the available processing time (channel), first for ATCRBS functions and then for DABS functions. This is possible because DABS employs monopulse direction finding; a technique using a rotating fan beam antenna with a sum pattern and a difference pattern. The interrogation is transmitted, and the reply received on the sum and difference patterns. The ratio of the amplitudes of the signals received on the difference and sum patterns is used to determine the off-boresight angle of the target; i.e., the angular difference between the target position and the antenna pointing angle.

Reliable and improved ATCRBS surveillance data are obtained with a nominal four "hits" per target contrasted to today's ATCRBS of 16 to 30 hits per target. A DABS period is the time interval between the end of an ATCRBS listening period and the next ATCRBS interrogation. The DABS period is used to perform DABS surveillance and data link communications.

DABS surveillance interrogations are scheduled in range order. In each antenna beam dwell, the DABS sensor first interrogates the DABS aircraft furthest from it. It computes the expected arrival time of the reply, and times the interrogation of the next furthest aircraft so that the replies will arrive at the sensor in sequence but not overlapped. It continues interrogating succeeding aircraft at decreasing ranges until the first reply is expected, then schedules a "listening" period to receive the replies to its interrogations. It repeats this procedure, interrogating all targets in line-of-sight during one "rollcall" schedule.

Only aircraft on the sensor's rollcall list can be discretely interrogated. To acquire targets not yet on the sensor's rollcall list, DABS transmits, when in the ATCRBS mode, an ATCRBS/DABS "All-Call" interrogation, which is similar to today's corresponding ATCRBS interrogation with an additional pulse—P4. An ATCRBS transponder is unaffected by the presence of the P4 pulse and responds with a normal ATCRBS reply. DABS transponders recognize the interrogation as a DABS All-Call interrogation and respond with a DABS All-Call reply containing its discrete address.

After determining the position and velocity of a DABS-equipped aircraft, the sensor places the target on its rollcall list. On a subsequent discrete interrogation, the DABS transponder can be locked-out from replying to All-Call interrogations, thereby eliminating unwanted replies. In the ATCRBS mode, DABS transmits a P2 suppression pulse on the omnidirectional antenna each time there is an ATCRBS/All-Call interrogation, just as is presently done to suppress ATCRBS transponders outside of the antenna's main beam. In the DABS mode, each discrete interrogation consists of a preamble of P1-P2 suppression pulse pairs to suppress ATCRBS transponders that are in the antenna main beam when the particular DABS target is being interrogated. This intentional suppression (nominally 35 microseconds (μs)) is to prevent unwanted ATCRBS replies from being triggered by a discrete interrogation.

Each DABS reply consists of a four-pulse preamble, which is designed to make the DABS reply easily distinguishable from an ATCRBS reply. DABS replies can be 56 μs or 112 μs long as compared with an ATCRBS reply which is nominally 20.3 μs.

The standard 56-bit message field of the DABS sensor's interrogation and the DABS transponder's reply will direct a wide range of ATC automation functions.

Extended-length message (ELM) capability provides transmission of up to 16, 80-bit message segments. This is provided to accommodate the needs of the more sophisticated airborne installations, including transfer of teletype and other long messages between the air and ground.

DABS has high message reliability, afforded by differential phase shift keying (DPSK) modulation, in which a phase reversal of the radiofrequency (RF) carrier indicates a binary "one" and an absence of a reversal indicates a "zero." DPSK provides interference immunity, fade margin, and multipath immunity which are superior to such other modulation techniques as pulse amplitude modulation. DABS employs a variation of pulse amplitude modulation, known as pulse position modulation, for its replies. This provides reliable bit detection in the presence of ATCRBS inteference and assures constant energy for accurate monopulse angular measurements. DABS uses an error detection and correction scheme which places parity bits in the address field. The result of this coding is that an error anywhere in the message will alter its address. The transponder will not reply to an interrogation containing an error because the interrogation does not appear to be addressed to this particular transponder. The sensor will sense an error in a reply because it is awaiting a reply from only one specific aircraft whose address is known. Using its knowledge of the correct address, the sensor can perform error correction on DABS replies, even in the presence of asynchronous ATCRBS replies.

To perform many of its functions, DABS incorporates a distributed computer architecture. This architecture features the multiple use of common modules such as computers, memory couplers, data buses, and modems. The application of redundancy at the module level supports the high reliability requirements of DABS. Common backup (as standby units) is provided on-line for each module type such that failure/recovery, in general, can be accomplished at the local level without major perturbation to the remainder of the system. All communication between computers is through global memory such that, each computer with its tasks becomes an independent subsystem. If a computer fails, its tasks can be switched automatically to another computer with minimum interference with the rest of the system.

DABS computers are grouped into ensembles with up to four computers in each ensemble. These computers are connected to an ensemble data bus through which they communicate with the rest of the system. Each DABS computer consists of two central processors, voting logic for the central processors, and 8,192 bits of local error-correcting code memory. The code of a DABS computer is executed simultaneously by each central processor. Results from the central processor executions are compared (or voted). If results agree, they are passed on to their destination; otherwise, the DABS computer involved is immediately switched off-line to prevent any erroneous data from being passed to the data bus and on to the global memory.

The DABS employs 36 computers of which 6 are redundant. Each of the 30 required computers has a different load module, depending on the particular system task being performed in that computer. Furthermore, each of these computer load modules is available in global memory and can be downloaded, if required, into a redundant computer. This is the end result of the failure/recovery process for computer failures.

It should be noted that in the test configuration, one of the six redundant computers was executing an extension of data extraction software and was, therefore, not available to replace a failed computer. The effect was only a reduction in the number of computer failures from which recovery can be made.

The sequence of events for computer failure/recovery is essentially as follows:

1. Error detection hardware within the computer detects the failure. Error checks include bit comparisons between the two identical arithmetic units (AU) of the computer and uncorrectable memory errors while accessing local memory.

2. The faulty computer generates an interrupt which causes all nonredundant computers to cease processing. The interrupt is removed when the faulty computer replacement is complete, at which time all computers resume processing.

3. The faulty computer's interrupt causes the failure/recovery computer to examine computer status registers to determine which computer is faulty. When this has been determined, failure/recovery references global memory tables to determine which load module had been assigned to the faulty computer and which redundant computer is available to replace the faulty computer.

4. Failure/recovery completes the process by causing the available redundant computer to download the required load module by changing the assignment tables in global memory, and by removing the faulty computer's interrupt to allow all computers to resume.

The computer failure/recovery process logic has additional capabilities to account for special cases. For example, the ATCRBS reply-to-reply processor is restricted to reside on the ATCRBS Tiline for convenient access to the ATCRBS reply data arriving there. Therefore, one redundant computer resides on the ATCRBS Tiline and is reserved for use there rather than replacement of faulty computers elsewhere.

Special logic also exists to cover the cases of failure of the redundant computers themselves, including failure/recovery. To accomplish this, the redundant computers are given a hierarchy of responsibilities. Each redundant computer is responsible for determining whether or not the computer failure has occurred in another redundant computer of higher rank. For example, if failure occurs in the failure/recovery computer, this is recognized by a redundant computer of lesser rank known as primary standby.

FUNCTIONAL DESCRIPTION FOR THE BASELINE DISCRETE ADDRESS BEACON SYSTEM OF THE ENGINEERING MODEL. The functional architecture of the sensor is illustrated in figure 1. The sensor functions are conveniently categorized according to the time scale on which they operate, as follows:

1. Those which involve the generation and processing of signals, and operate on a microsecond time scale; e.g., modulator/transmitter, multichannel receiver, and DABS and ATCRBS reply processors.

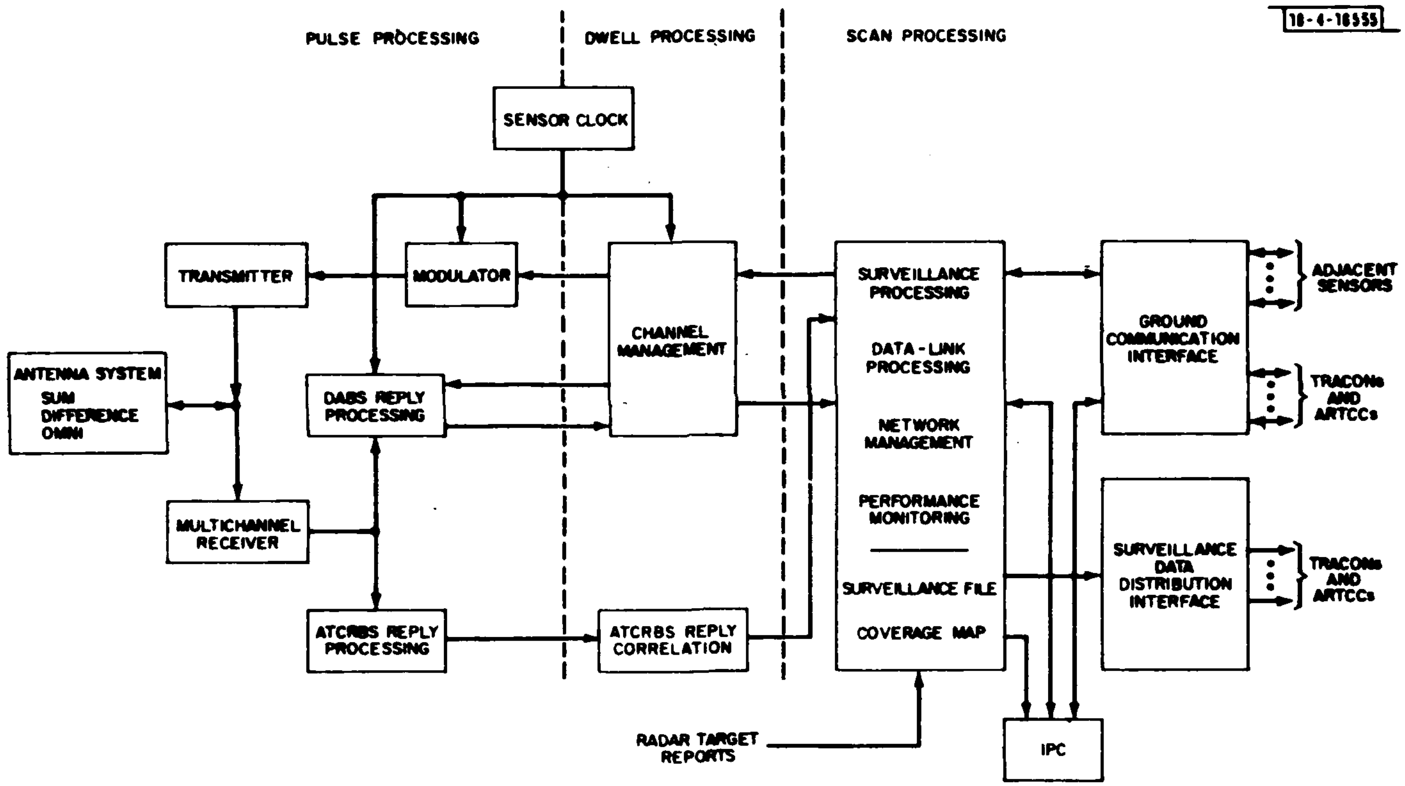

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FIGURE 1. DABS SENSOR FUNCTIONAL BLOCK DIAGRAM

2. Those which involve channel transactions, and operate on a millisecond time scale, commensurate with the dwell time of the interrogator antenna on a target; e.g., channel management and ATCRBS reply correlation.

3. Those which are paced by the antenna scan time, and operate on a 1-second time scale; e.g., surveillance processing, data link processing, network mangement, performance monitoring, and ATARS.

The transmitter-modulator control generates all waveforms and RF signals in the ATCRBS and DABS modes for transmission through the antenna. The multi-channel receiver provides the path from the antenna to the processors for the DABS and ATCRBS aircraft replies.

The channel management function determines the nature and timing of each event taking place on the RF channel. Channel management controls both the ATCRBS and DABS activities of the sensor in accordance with a site adaptable input table.

DABS has an adaptive reinterrogation capability. In the event of a failure to receive a DABS reply, channel management will reschedule an interrogation during the same antenna beam dwell, providing high surveillance and communication reliability.

The ATCRBS processor accepts video inputs from the receiver and provides ATCRBS target replies. These target replies consist of range, azimuth, one of 4,096 beacon identity codes, altitude codes, ATCRBS confidence, monopulse average, and time. The ATCRBS reply-to-reply correlation function is performed by a software algorithm and outputs target reports.

DABS target reports consist of an estimate for range and azimuth, and the information bits that have been transmitted as part of the reply. Using error flags and error-correcting codes, the DABS processor will give an indication whenever a reply has been received unsatisfactorily. The unsatisfactory reply condition is relayed to the channel management function so that another DABS interrogation can be scheduled for that particular aircraft during the same beam dwell.

The surveillance file processing function maintains target files on all ATCRBS and DABS aircraft within the sensor's coverage volume. Its principal functions are to:

1. Predict next-scan position of DABS aircraft for interrogation scheduling.

2. Edit and correct ATCRBS target reports based upon data from previous scans.

3. Perform track initiation.

4. Accomplish target-to-track correlation.

5. Perform radar/beacon correlation of target reports from a collocated radar.

6. Disseminate composite ATCRBS/DABS radar surveillance data to ATC users.

The surveillance processing function performs DABS and ATCRBS scan-to-scan correlation. Beacon reports are correlated with digitized primary radar reports. These reports are transmitted to ATC facilities as "radar reinforced" beacon reports. Radar substitution reports, in beacon format, are transmitted to ATC for those radar reports correlating with beacon tracks. Radar reports which do not correlate with either a beacon report or beacon track are classified as "radar only" reports. Radar only scan-to-scan correlation is also performed by surveillance processing depending upon the type of primary radar digitizer interfaced with DABS. Scan-to-scan radar correlation is performed for the moving target detector (MTD) and sensor receiver and processor-1 (SRAP-1), although not for the common digitizer (CD). Uncorrelated CD radar reports are transmitted to ATC facilities as uncorrelated radar only reports.

The data link processor provides the message link between the ATC facilites and the sensor. Downlink messages are passed through the data link processor and forwarded to the designated ground-based user. Uplink messages, sent from the ATC facilities, are formatted and listed in the data link file with their priority and appropriate tags to indicate message type.

Sensor performance monitoring is accomplished by measurements within the sensor and loop measurements between the sensor and the remotely located calibration performance monitoring equipment (CPME). The CPME will reply to special test interrogations, and these replies will be compared with expected results that have been stored to determine if the sensor is performing properly.

The failure/recovery function provides for the removal of failed system components; replacement is by redundant components. The system components for which redundancy is provided are: (1) ensembles, (2) global memory, (3) computers, and (4) modems.

Some failures can result in the loss of an ensemble of four computers. For example, the power source for the ensemble may fail. The recovery process for such events is initiated by interrupts. As in the single computer failure/recovery case, all nonredundant computers cease processing. The failure/recovery computer begins the investigative logic required to determine the location of the fault. As before, a hierarchy of redundant computer responsibilities provides for special cases, such as failure/recovery, having been resident on the bad ensemble.

When the faulty ensemble has been isolated, the recovery process proceeds as if four consecutive computer failures had occurred. Thus, at conclusion, the four computer load modules previously resident on the faulty ensemble will have been downloaded into four available redundant computers. Assignment tables in global memory will reflect the new configuration, and the initial interrupt will have been removed to release the nonredundant computers.

Each global memory module has a uniquely associated backup module. The components of these pairs are called the primary and secondary modules of the pair. Management of the pair is accomplished by the memory monitor hardware located separately from the memory itself, and by the software failure/recovery logic executed by the failure/recovery computer.

During normal operation, every global memory write results in identical operand data which is stored in both the primary and secondary module. Every global memory read results in an operand fetch from only the primary module. However, the read hardware of the secondary module is exercised simultaneously, and any unrecoverable read error is detected in either module independently.

In the event that a failure occurs in a secondary module, it is recorded in the memory monitor hardware and no further immediate action is required. At a later time, performance monitor software notes the failure of backup memory and initiates the appropriate message from the sensor.

If an unrecoverable read error occurs in a primary module, an interrupt is generated. The failure/recovery computer examines status registers to isolate the failure to a specific primary module. Appropriate control data are then provided to the memory monitor hardware.

The new control data, provided by the primary standby computer to the memory monitor hardware, causes all future reads to be made from the secondary module in which an exact copy of data has been maintained. Redundant writing to or reading from the primary module ceases.

On completion of the appropriate memory module management control, the computer, which originally experienced the fault and aborted memory fetch, is restarted and the recovery process is complete.

The DABS communication subsystem includes multiple channels. Each channel includes a modem and a digital control board known as a Comm board.

These channels are grouped into two subsets, one for surveillance data communications and one for Common International Civil Aviation Organization (ICAO) Data Interchange Network (CIDIN) data communications. Each subset group is provided with a redundant channel capable of switching in to replace a faulty one. On the telephone line side of the modems, the switch is accomplished by hardware resident on the link switchboard. On the internal side of the Comm boards, the switch is accomplished by software.

If a fault is detected in a channel, recovery software provides control data to the link switch hardware to cause the telephone line side of the redundant channel to be connected to the phone line. Tables in global memory are then modified to cause the communications software to use the redundant Comm board rather than the Comm board in the faulty channel.

When this recovery process is applied to a surveillance data channel, the recovery is complete at this point. Any resultant loss of surveillance data is permissible. However, CIDIN channel recoveries require that certain types of CIDIN messages be retained. Thus, completion of the recovery requires that the CIDIN messages be repeated. The message recovery is done by software under the dictates of the CIDIN protocol.

The CIDIN protocol is used on all two-way site-to-site communications within the DABS network. This protocol is specified by ICAO for use on all international ground-to-ground data interchanges. This protocol uses cyclic redundancy checking (CRC) on the contents of each message plus positive acknowledgement or retransmission request to ensure that each message is correctly delivered.

A front-end processor (FEP) is provided to an ATC center for the purpose of performing the CIDIN protocol functions. This FEP interfaces on the CIDIN side with all of the DABS sensors. The FEP connects through a high speed interface to the 9020 central computer complex. The messages received from the DABS sensors over the CIDIN links are transmitted to the 9020 over this interface, as well as messages from the 9020 destined for the DABS sensors.

The ATARS function resides in the DABS computer subsystem. ATARS receives surveillance inputs from DABS through the surveillance buffer. ATARS communicates with the local sensor and adjacent sensor's ATARS function through the communications (nonsurveillance) buffer. ATARS uses the surveillance data to generate its own track file and position predictions. From these, predictions of potential conflict situations are made; advisory and conflict resolution messages are sent to the aircraft involved via the DABS data link.

DISCUSSION

TEST OBJECTIVES/APPROACH.

The objective of the DABS test and evaluation was to determine the baseline performance characteristics for the following functional areas: surveillance, failure/recovery, communications, reliability, and sensor-to-ATC interface. In addition, DABS/ARTS target reporting performance was compared. The testing was conducted with the following constraints:

1. The system load module was "frozen" with TI software release 6.3. A load tape was built for the T&E effort and used throughout the testing at NAFEC.

2. Site-adaptable parameters were determined prior to the start of testing and, except for several in the performance monitor area, they remained the same throughout the testing.

3. Proposed modifications to the system load module were evaluated in the system, but were then removed and not incorporated for this phase of testing. Improvements in performance brought about because of proposed modifications

to the load module are discussed in the SUMMARY OF RESULTS section of this report. However, any secondary effects of the changes were not fully ascertained.

The Aircraft Reply and Interference Environment Simulator (ARIES) and scenarios, developed for surveillance capacity peak sector loading and communications evaluation, were used extensively to determine the performance characteristics. The scenarios were run and rerun with a variety of target and environment parameters such as beacon round reliability (R/R), radar blip scan (b/s), ATCRBS fruit, and DABS fruit rates. Figure 2, the DABS T&E matrix, defines the tests and the parameters. Test aircraft equipped with DABS transponders, targets of opportunity, software drivers, and mechanical switches wired to different computers to simulate voting failures were also used to ascertain DABS performance.

The scenario information was input to DABS through the ARIES interface. Data extraction tapes of the ARIES and DABS outputs for all runs were collected and analyzed. The NAFEC-developed data reduction and analysis (DR&A) routines were used to determine the performance characteristics discussed in the SUMMARY OF RESULTS section of this report. Figure 3 defines the test environment.

Performance data were evaluated for the terminal facility using a standard ATCRBS 5-foot antenna. The following defines the target and environmental parameters selected for use during the T&E, the method of generation (where applicable), and the reasons for the selected values.

TARGET AND ENVIRONMENTAL PARAMETERS.

ATCRBS FRUIT (ASYNCHRONOUS REPLIES). The ATCRBS fruit added to the scenarios were generated by ARIES. The fruit rate, as selected in the ARIES environmental file, represents the total fruit which would enter a directional antenna. A second parameter, the main beam/side lobe ratio, defines what percentage of the fruit received by the directional antenna occurred within the antenna main beam. Measurements of real world fruit (at the NAFEC ASR-7 facility), using the ATCRBS 5-foot antenna and the DABS sensor, indicated a fruit rate between 500 to 1,000 per second. Of this total number, approximately 25 percent was main beam fruit.

The scenario fruit rates were selected to be 0, 4,000, and 44,000 per second. The 4,000 per second rate simulates the present fruit environment encountered in areas such as New York City or Los Angeles. The 44,000 per second rate was chosen to generate eight main beam fruit per sweep within the 60-nmi range of a terminal facility in accordance with the FAA-ER-240-26 capacity requirement.

DABS FRUIT (ASYNCHRONOUS REPLIES). The DABS fruit added to the scenarios were generated by the DABS asynchronous reply generator. All of these fruit replies were in the main beam of the antenna and comprised of 56-μs and 112-μs message lengths having a mixture of 75 percent and 25 percent, respectively. Three DABS fruit rates were selected for baseline simulation tests, 0, 50, and 200 per second.

Test No.	Scenario Description	Aircraft Type DABS/ATCRBS/MIXED	Terminal En Route	ATCRBS Fruit Rate	DABS Fruit Rate	Beacon Round/Rel	Radar Blip Scan	Comments
1	Probability of Detection	A	T	0	0	0.95	0	
2	Probability of Detection	A	T	44K	0	0.95	0	
3	Probability of Detection	D	T	0	0	0.95	0	
4	Probability of Detection	D	T	0	200	0.95	0	
5	Probability of Detection	A	T	44K	0	0.95	0	
6	Basic	A	T	0	0	0.95	0.8	
7	Basic	D	T	0	0	0.95	0.8	Comm A/B Delivery
8	Basic	M	T	0	0	0.95	0.8	Comm A/B Delivery
9	Basic	M	T	44K	200	0.95	0.8	Failure Recovery Test
10	Basic	A	T	4K	0	0.95	0.8	
11	Basic	D	T	0	50	0.95	0.8	Comm A/B Delivery
12	Basic	M	T	4K	50	0.95	0.8	Comm A/B Delivery
13	400 Targets in 90° Wedge	M	T	44K	200	1.00	0.8	
14	Basic	M	T	44K	200	0.95	0.8	Failure Recovery Test
15	Basic	M	T	4K	50	0.95	0.8	Failure Recovery Test
16	Basic	M	T	4K	50	0.95	0.8	Failure Recovery Test
17	Basic	A	T	44K	0	0.95	0.8	
18	Basic	A	T	4K	0	0.95	0	
19	Basic	D	T	0	200	0.95	0.8	Comm A/B Delivery
20	Basic	D	T	0	50	0.95	0	
21	Basic	M	T	44K	200	0.95	0.8	Comm A/B Delivery
22	Basic	M	T	4K	50	0.95	0	
23	Live World	Controlled ATCRBS	T	--	--	--	--	
24	Live World	Controlled DABS	T	--	--	--	--	
25	48 Targets in 4°	M	T	44K	200	0.95	0.8	
26	48 Targets in 4°	D	T	44K	200	0.95	0.8	Comm A/B Delivery
27	Basic	M	T	44K	200	0.95	0.8	Failure Recovery Test
28	Basic	M	T	44K	200	0.95	0.8	Failure Recovery Test
29	Basic	A	T	0	0	0.70	0.8	
30	Basic	D	T	0	0	0.70	0.8	
31	Basic	M	T	0	0	0.70	0.8	
32	Basic	A	T	4K	0	0.70	0.8	
33	Basic	D	T	0	50	0.70	0.8	
34	Basic	M	T	4K	50	0.70	0.8	
35	Basic	A	T	44K	0	0.70	0.8	
36	Basic	D	T	0	200	0.70	0.8	
37	Basic	M	T	44K	200	0.70	0.8	
38	400 Targets in 360°	M	T	44K	200	0.95	0.8	Comm A/B Delivery
39	Basic	M	T	44K	200	0.70	0.8	Failure Recovery Test
40	Basic	M	T	44K	200	0.70	0.8	Failure Recovery Test
41	Basic	M	T	44K	200	0.70	0.8	Failure Recovery Test
42	Basic	A	T	4K	0	0.70	0	
43	Basic	D	T	0	50	0.70	0	
44	Basic	M	T	4K	50	0.70	0	
45	Basic	A	T	0	0	0.95	0.8	
46	Basic	A	T	4K	0	0.95	0.8	
47	Basic	A	T	44K	0	0.95	0.8	
48	Basic	A	T	0	0	0.70	0.8	
49	Basic	A	T	4K	0	0.70	0.8	
50	Basic	A	T	44K	0	0.70	0.8	
51	Basic	A	T	4K	0	0.95	0	
52	Basic	A	E	4K	0	0.95	0.8	
53	Basic	D	E	0	50	0.95	0.8	Comm A/B Delivery
54	Basic	M	E	4K	50	0.95	0.8	Comm A/B Delivery
55	400 Targets in 90°	M	E	44K	200	1.00	0.8	
56	Basic	M	E	44K	200	0.75	0.8	F/R
57	Basic	M	E	44K	200	0.75	0.8	F/R
58	Live World	Controlled ATCRBS	E	--	--	--	--	N-48
59	Live World	Controlled DABS	E	--	--	--	--	N-48
60	Basic	A	E	44K	0	0.75	0.8	
61	Basic	D	E	0	200	0.75	0.8	
62	Basic	M	E	44K	200	0.75	0.8	
63	Basic	A	E	44K	0	0.75	0.8	
64	Basic	M	E	44K	200	0.75	0.8	F/R
65	400 Targets in 360°	M	E	44K	200	0.95	0.8	Comm A/B Delivery
66	48 Targets in 4°	M	E	44K	200	0.95	0.8	
67	48 Targets in 4°	D	E	44K	200	0.95	0.8	Comm A/B Delivery
68	Live World	--	T	--	--	--	--	No Controlled A/C
69	Live World	--	T	--	--	--	--	N-48
70	Live World	--	T	--	--	--	--	N-48
71	Basic M-26	M	T	4K	50	0.93	0.8	F/R
72	Basic M-26	M	T	4K	50	0.93	0.8	F/R
73	Basic M-26	M	T	4K	50	0.93	0.8	F/R
74	Capacity L.A. Basin	M	T	0	0	1.00	0	DABS Inter. Rate
75	---	--	--	--	--		--	
76	Turning T-112	D	T	0	0	1.00	0.8	
77	Turning T-115	D	T	0	50	1.00	0.8	
78	Turning T-115	D	T	0	200	1.00	0.8	
79	Turning T-114	A	T	0	0	1.00	0.8	
80	Turning T-114	A	T	4K	0	1.00	0.8	
81	Turning T-114	A	T	44K	0	1.00	0.8	
82	Live World	--	T	--	--	--	--	N-50
83	Live World	--	T	--	--	--	--	N-50
84	Live World	--	T	--	--	--	--	F/R
85	Turning T-115	D	T	0	0	1.00	0.8	Modify Range
86	Turning T-115	D	T	0	50	1.00	0.8	Guard Constant
87	Turning T-114	A	T	4K	0	1.00	0.8	K=2 In Sensor
88	Live World	--	E	--	--	--	--	Comm A/B
89	Turning	D	E	0	50	1.00	0.8	
90	Turning	A	E	4K	0	1.00	0.8	

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FIGURE 2. DABS T&E MATRIX

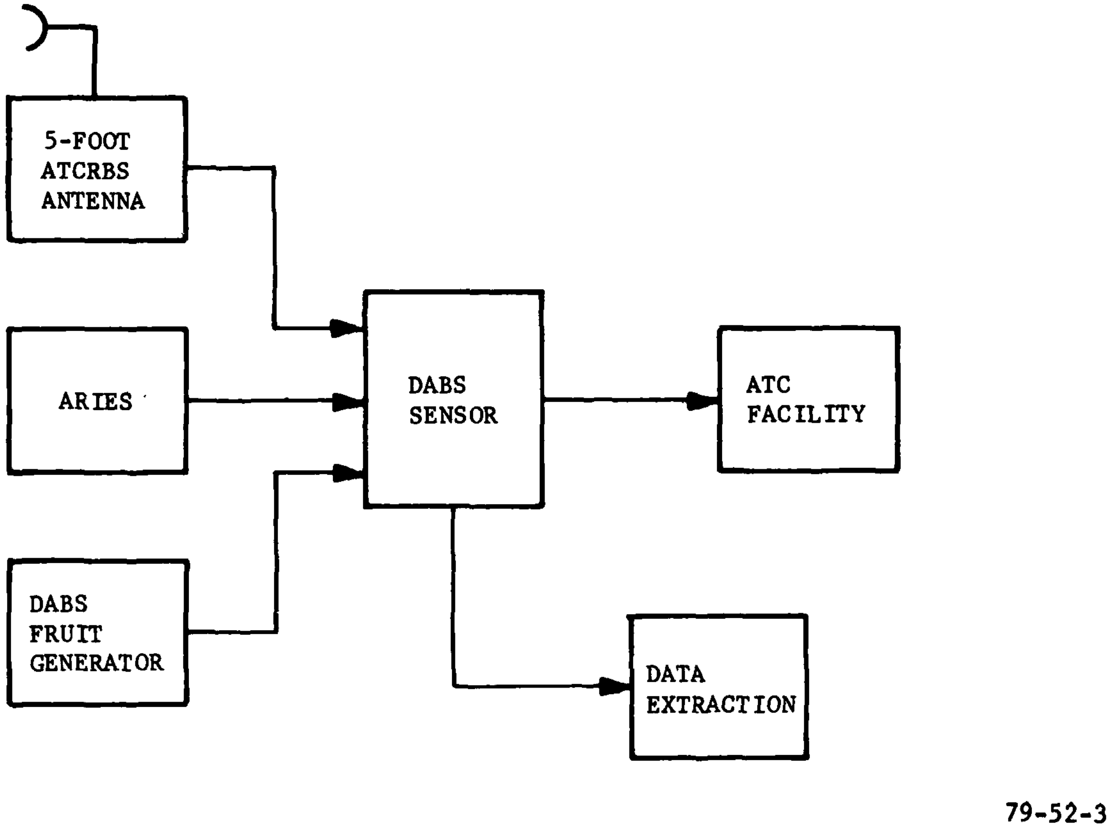


FIGURE 3. TEST ENVIRONMENT

BEACON ROUND RELIABILITY (R/R). Beacon R/R was the percentage of replies received from an aircraft compared to the number of interrogations directed to the aircraft. During the generation of the ARIES scenarios the R/R for each of the targets was predetermined by selection of a reply probability for each aircraft.

The values 0.935 and 0.688 were chosen as test inputs. An R/R of 0.935 was representative of a good value. An R/R of 0.688 was representative of a worst-case situation, as well as determining sensor performance at very low R/R. Limited pretest data were collected at the DABS sensors showing a variation of R/R from 0.90 to 0.80.

RADAR BLIP SCAN (b/s). The radar b/s was the probability of receiving a radar report from a selected target on a given scan. It has the same value for all scenario targets and was determined by setting parameters in the ARIES environmental file on the disk.

Radar b/s of 0 and 0.8 were used for the basic scenarios and 0.2 for the peak capacity runs. The 0 b/s represents beacon reports only, while the 0.8 b/s is presently encountered in a real world environment.

SITE ADAPTABLE PARAMETERS. There were approximately 400 parameters associated with DABS that were adaptable by means of a software entry. During the baseline T&E, the ATCRBS pulse repetition frequency was set to 128, to provide a maximum average of four hits per beam dwell, and scan rate to 12.85 revolutions per minute (rpm). The remainder of these 400 parameters were maintained at the nominal values at which they were set when the sensor was delivered, except for several associated with the performance monitor. When performing T&E at the higher fruit rate of 44,000 replies per second, it was necessary to adapt the thresholds for receiver gain and receiver noise to a value that prevented the sensor from declaring a red operational status and thus aborting the test. These parameters were returned to their nominal values at the conclusion of the high fruit rate tests.

TEST CONFIGURATION.

The following paragraphs describe various items associated with the T&E of the sensor. These include simulators and test equipment as well as the software required to support T&E.

AIRCRAFT REPLY INTERFERENCE ENVIRONMENTAL SIMULATOR (ARIES). The ARIES was designed by Lincoln Laboratory to simulate DABS/ATCRBS target replies, ATCRBS fruit replies, Comm messages, and radar data. The interrogation interface between the sensor and the ARIES was at the RF level; and the replies generated by the ARIES were inputted to the DABS at the receiver IF level. Radar interface was accomplished via the DABS communications subsystem, as normally accomplished for radar. Various traffic samples were selected to test DABS under air traffic environments anticipated through 1995. Several different scenarios, as discussed in the TEST SCENARIO section and appendix A, were generated for repeated playback through the ARIES. The scenarios were run and rerun with a variety of target and environment parameters.

Along with the simulated traffic, ARIES generated a simulated fruit environment. The arrival times of fruit replies were not based on the traffic model. To do this would require modeling the nearby interrogators that cause these interfering replies to be generated. Instead, fruit was modeled as a random process with Poisson statistics. The operator can control the average fruit rate by setting parameters in a file on the system disk.

ARIES is capable of generating ATCRBS fruit replies at rates up to about 50,000 replies per second. DABS fruit was not generated by ARIES. These high rates were required to test the performance of the DABS sensor's reply processing circuitry at the interference levels at which it is capable of operating.

For both the simulated transponder (controlled) replies and fruit replies, ARIES provides the necessary signals to accurately simulate the monopulse off-boresight angle. Also, an omnidirectional signal was provided so that sidelobe replies could be simulated. These signals were connected to the DABS sensor via an interface dedicated to ARIES. The sensor added these signals to similar signals from the sensor's antenna. This allowed a simulated environment to be superimposed on a live environment.

A maximum of 400 targets was simulated by ARIES. Any mix of DABS and ATCRBS targets was possible. In addition to the overall limitation on the number of targets, there were limitations on the number of targets bunched in azimuth. ARIES was capable of generating the number of bunched targets specified for the DABS sensor, which are:

1. Fifty aircraft in an 11.25° sector, for not more than eight consecutive sectors.

2. Twelve aircraft in 1.0° azimuth wedge for up to four contiguous wedges.

In addition to the beacon data, ARIES provided simulated digitized radar data in the output format of the CD. The radar targets correspond to the simulated beacon targets. The reported coordinates were those seen by a primary radar whose antenna rotates with the beacon antenna about the same axis. The ARIES operator can control the radar reply probability by setting parameters in file on the system disk.

The ARIES equipment consisted of interrogation receiving circuitry, reply generation circuitry, and a computer with associated peripheral equipment to control the system. This equipment was housed in two standard racks. A complete description of ARIES is contained in Report No. ATC-87.

DABS ASYNCHRONOUS REPLY GENERATOR (FRUIT). The DABS fruit generator was designed and fabricated by NAFEC personnel and provided repeatable pseudo-random DABS replies input to the internal DABS RF test unit (RFTU). The output of the RFTU, an RF signal, was input to the receiver and appeared to the DABS as asynchronous (fruit) replies from DABS transponders. Fruit rates, long and short reply mixtures (56- and 112-bit messages), and bit configurations were switch selectable on the reply generator.

The DABS message output from the asynchronous reply generator was a serial data stream of either 56 or 112 μs in duration. There were 14 unique 112-bit messages. All of the simulated replies represented messages that can occur in a live environment. Each message contained the correct address/parity field.

ANTENNA CONFIGURATION. The beacon antenna originally planned to support testing of the DABS engineering model was to have a gain of 25 decibels (dB) above isotropic and a 3-dB beam width of 4°. However, in order to satisfy a recent airway facilities implementation requirement, an ATCRBS 5-foot antenna with a nominal gain of approximately 22 dB above isotropic and a 3-dB beam width of 2.4° was used. The ATCRBS 5-foot antenna is 26 feet in length with an array of 35 columns of 10 dipoles each, and provides improved system performance because of its shaped elevation pattern and sharp horizon rolloff. An integral omnidirectional antenna provides sidelobe suppression (SLS) performance without the sum/SLS elevation pattern differential lobing inherent in the hogtrough antenna system. Also included in the antenna group was a backfill antenna assembly that comprised half of the SLS system providing SLS coverage for the rear region. This backfill assembly was tilted to compensate for any tilt to which the array may have been subjected.

DABS TRANSPONDER. The fundamental difference between a DABS transponder and an ATCRBS transponder is the manner of soliciting a response. In ATCRBS, the selection is spatial; whereas in DABS, the transponder responds to an interrogation having only its unique address. To facilitate the transition from ATCRBS to DABS over an extended period, the DABS transponders are capable of replying to both DABS and ATCRBS interrogations. The DABS transponder used during the baseline T&E responded to all DABS interrogation types except for ELM, and to all ATCRBS interrogations except for mode 2. In addition, the transponder had the capability to operate in an antenna diversity mode. The transponders under a current Bendix contract will have the ELM capability which will be tested later in the program.

CALIBRATION PERFORMANCE MONITORING EQUIPMENT (CPME). The CPME is a special purpose test transponder used to verify DABS sensor monopulse azimuth accuracy, to calibrate the sensor off-boresight azimuth look-up table, and for checking DABS data link integrity. It provides a method for performing a full loop system check. The CPME is permanently installed at a surveyed location within the coverage pattern of one or more DABS sensors, and is assigned its own DABS discrete address. The positional accuracy of the CPME site is to a third order survey having an angle accuracy of ±0.0028°, a direction accuracy of ±5 feet, and an elevation accuracy of ±1 foot. The CPME responds to ATCRBS mode A- and mode C-code interrogations and to all DABS interrogations except for ELM. The CPME was contained within a weatherproof enclosure which permitted it to operate unattended over a wide range of environmental conditions. A complete description of the CPME is contained in Report No. FAA-RD-78-151, "The DABS Calibration Performance Monitoring Equipment."

COMMUNICATION (Comm) A/B DRIVER. The function of the Comm A/B driver was to simulate an ATC facility by storing aircraft-destined messages into the incoming Comm buffer. Five different Comm A messages were stored for processing by the sensor: tactical uplink, ELM uplink, request for downlink, ATCRBS identification (ID) request, and data link capability request. The sensor routed the messages as they were stored in the incoming buffer and stored the replies in the outgoing Comm buffer. Both the incoming and outgoing Comm buffers were recorded on the sensor data extraction tape for analysis.

Through the use of separate data blocks, the driver supported three scenarios: basic 42-aircraft scenario, 48-in-the-beam scenario, and the capacity scenario. Each data block contained tables outlining the schedule for the associated scenario; i.e., type code of message to be sent to each aircraft, scan number on which message was to be sent, DABS ID for each message, and expiration time for each message. The data block was set up to cause the driver to cycle through a set of messages for a specified number of times.

INTERFACE SOFTWARE. Testing of the interfaces between the DABS sensors and the NAFEC ATC facilities was accomplished using interface software in the System Support Facility (SSF) and Terminal Area Test Facility (TATF). Two distinct but functionally similar versions of the interface software were used. The first of these, executed on the International Business Machines (IBM) 9020 computer of the SSF, was known as DABS interface verification (DABSIV). The second executes on the input/output processor (IOP) of the ARTS III computer in the TATF and is known as terminal interface verification (TIV). The DABSIV package provided a data interface with up to three DABS sensors. Surveillance data were accepted by the program and optionally recorded and/or summarized on-line. Communications data received from the FEP were processed in accordance with the 9020/FEP protocol. These data were optionally recorded, summarized, and/or printed on-line. Additionally, a scenario input tape was optionally used as a source of messages to send to any combination of the three DABS sensors.

A companion data reduction package (DIVAR) was used to reduce the surveillance and communication recording tapes. Messages were summarized and/or printed. Under either option, data to be reduced were specified by time, adaptor or sensor, aircraft identification, or message type.

Detailed descriptions of these programs can be found in the:

1. "En Route Interface Verification Software for the Discrete Address Beacon System," Functional Design Specification, NAFEC, July 1977, revised January 26, 1978.

2. "User's Manual for Discrete Address Beacon System (DABS) Interface Verification (IV)," CSC/TM-78/6157, Computer Sciences Corporation, June 1978, revised December 1978.

3. "NAS Operation Support System User's Manual for Discrete Address Beacon System Interface Verification (DABSIV) Off-line Data Reduction and Analysis Program (DIVAR)," CSC/TM-78/6155, Computer Sciences Corporation, June 1978, revised June 1979.

The TIV package provided a data interface with a single DABS sensor. Surveillance and communication data were accepted by the program from the communication multiplexer controller (CMC). Summaries of the data received and transmitted were presented on a cathode ray tube (CRT) display, along with the contents of specified types of communication messages which may optionally be displayed. A scenario input tape was optionally used to generate messages sent to the sensor or entered from the keyboard. All messages transmitted and received were optionally recorded on an extractor tape.

A companion data reduction package was used to reduce the extractor tape. Data were summarized and/or printed. Data to be reduced were specified by type, message type, time, adaptor, or aircraft identification.

Detailed descriptions of these programs can be found in the:

1. "Terminal Interface Verification Software for the Discrete Address Beacon System," Functional Design Specification, NAFEC, September 1977.

2. "DABSEM/ARTS III Terminal Interface Verification Program User's Manual," ATC 10305, Sperry Univac Defense Systems, August 1979.

SCENARIOS. The scenario generation program was developed by TI for use on the IBM 370 computer. NAFEC programmers made several modifications and adapted the program to run on the NAFEC Honeywell 66/60 general purpose computer.

In support of the T&E effort, six categories of test scenarios were designed and generated. They were: (1) probability of detection (P_d), (2) basic 42-aircraft scenario, (3) turning targets, (4) 282 targets in a 90° wedge, (5) 48 targets in 4° wedge, and (6) 400 targets in 360°. The last three scenarios were designed specifically to verify the capacity and peak sector loading capabilities of the DABS. Each of six scenarios had been generated with various combinations of the following target types: all ATCRBS, all DABS, and a mixture of DABS and ATCRBS targets. The scenarios were developed for use at a terminal facility having a 60-nmi range.

The basic 42-aircraft scenario was overlayed on all of the capacity runs to serve as the subset of targets that would undergo an extensive analysis. The basic 42-aircraft scenario (except for four stationary targets used for synchronization) in groups, or individually, have been designed to present a variety of different encounter situations. For example: various intersection angles, overlapping pulse codes, turns, north mark crossings, zenith cone crossings, track swap possibilities, and other live world situations. A detailed discussion of the scenarios are contained in appendix A.

TEST CONDUCT.

The following summarizes the test procedures for each of the eight functional areas that were evaluated.

SURVEILLANCE. Surveillance performance characteristics were determined with simulated scenarios and real world targets. The P_d scenario was used to initially characterize the surveillance performance as a function of sensor input signal level. Attenuation was inserted in the ARIES-to-sensor signal lines so that the input levels at the sensor were representative of the signal strength expected from a target as a function of range. Additional performance measurements were obtained for a variety of different target encounters and maneuvers by using the basic 42-aircraft scenario (a complete description of this scenario is contained in appendix A). Surveillance performance in a capacity traffic and peak loading environment was ascertained by using the scenarios designed to simulate those situations. Because of difficulty dealing with the large numbers of targets on the capacity scenarios, analysis was restricted to the basic 42-aircraft woven into each of the scenarios.

Several tests with controlled DABS transponder-equipped aircraft were flown to measure the surveillance performance in a real world environment. The simulated tests were conducted with a variety of different target parameters as indicated in figure 2, the T&E matrix. All data collected during the surveillance T&E were evaluated by use of the NAFEC-developed DR&A. When necessary, desk analysis was performed.

FAILURE/RECOVERY. The DABS system includes redundant hardware items which are called upon in the event of certain hardware failures. The process of detecting these failures and replacing the faulty parts with redundant parts is done in real time, and the process is referred to as failure/recovery.

The failure/recovery design includes provision for computer failures, ensemble failures, global memory failures, and modem or modem control failures. Tests have been conducted at NAFEC to determine the integrity of sensor activity after failure/recovery processes have been invoked.

A total of eight tests were conducted on the DABS sensor at NAFEC to evaluate the operation of the failure/recovery hardware and software. These tests were specifically designed to exercise the sensor's recovery from multiple computer failures coupled with global memory and modem failures. Basically, these tests fall into two categories: ensemble failures and separate computer failures.

Four of the tests involved failing an ensemble of four computers, followed by failing global memory and a modem. An ensemble failure was invoked by turning off the alternating current (a.c.) breaker to the ensemble, thus causing the failure/recovery software to assign four spare computers to take over the "jobs" of the computers lost in the ensemble failure. A specially installed switch was activated to cause global memory to fail, requiring the hardware to access the redundant "back-up" memory. A modem failure was simulated by placing a modem in the "modem-check" mode, forcing the failure/recovery software to switch over to a redundant modem using its "link-switch" capability.

The other four tests involved failing four computers separately rather than as an ensemble. Each computer was equipped with a toggle switch which would cause it to "vote", requiring failure/recovery to assign a spare computer to take the place of the failed computer. After four computers were "voted", global memory and modem failures were invoked as above.

To exercise failure/recovery to the fullest extent, the computer and ensemble failures were carefully selected to include worst-case situations. For example, one of the tests required the arrangement of ensemble one to include the three channel management computers. In this test, the failure of ensemble 1 would result in a total failure of channel management.

Each of the failures within the eight tests were separated by 10 scans. The first failure was always invoked during scan 59; the second failure occurred in scan 69; and so on. This separation allowed the DABS sensor ample time to return to steady state before the remaining failures were invoked, enabling each failure to be analyzed separately.

COMMUNICATIONS. The DABS performance characteristics in the interchange of data between the ground facility and the aircraft, and the aircraft and the ground facility, were determined using simulated scenarios. The basic 42-aircraft scenario was designed to have three unique targets which were used to determine the communications performance. Two of these targets had flightpaths that kept them in conflict situations; the third target had a flightpath into and out of the sensor's zenith cone. The "B" bit was set on each of these aircraft on predetermined scans when the scenario was generated. Table A-1, appendix A, shows these flightpaths.

In order to simulate an ATC facility, which would ordinarily deliver communications requests to the sensor for transmittal to the aircraft, a software driver was used. The driver had the capability to deliver a variety of different Comm A message types. For example: Comm A with the altitude/identity (AI) bit requested ATCRBS ID from a DABS aircraft; Comm A with the reply length (RL) bit requested a long message response from the DABS aircraft. Data recordings were generated at both the ARIES and the DABS. An analysis of this data was performed using the NAFEC DR&A to determine that messages were delivered and responses were received as expected.

Since ARIES does not presently have the capability of responding to Comm C interrogations, the ELM function was not tested. However, this function will be tested with the new avionics.

SENSOR-TO-ATC INTERFACE. Following installation of the telephone lines for each of the sensors, a series of line tests was conducted utilizing Halcyon data line test sets. After determining that the lines met the minimum specifications required, they were made available for interconnecting the sensors and ATC facilities.

A series of modem tests was conducted utilizing Tele-Dynamics model 7914B data set testers to generate pseudorandom bit patterns. Various operating conditions were tested to determine their effect upon modem operation and to determine the optimum operating conditions for the DABS test bed.

Interface performance was evaluated utilizing the interface software. Message scenarios were developed for the two interface programs to match the ARIES scenarios.

Interface programs were used to record the communication message flow in both directions in addition to generating the simulated ATC messages. These programs also recorded all surveillance messages received from the sensors.

The CIDIN error recovery logic was tested using the arbitrary error response logic of the terminal interface software. This logic enabled various CIDIN error messages to be generated, even though the specific error had not occurred. Each of the specified CIDIN error conditions was tested.

The interface data reduction programs were used to reduce the collected data. The communication data were reviewed to determine that the proper response had been made to all messages. The surveillance data for selected aircraft were also reviewed.

RELIABILITY. The purpose of the reliability evaluation of the DABS sensor during the baseline testing period was to ascertain any weak points or problem areas in the system design. These manifest themselves by the occurrence of distinct or repetitive hardware failure patterns, as well as unusual difficulties encountered in diagnosing, isolating, and correcting these failures. Further details on the reliability aspects of the DABS sensor and the method of evaluation are contained in "Plan for the Reliability and Maintainability Evaluation of the Discrete Address Beacon System (DABS) Engineering Laboratory Models," FAA, Report No. FAA-NA-78-31 dated October 1978.

Data were collected on the NAFEC sensor during the period June 30, 1978, through July 31, 1979. Failure and maintenance data, as well as changes in operational status conditions, were recorded on Facility Maintenance Logs (FAA Form 6030-1) and Texas Instruments Trouble Reports by DABS site personnel. From these logs, each failure and change in operational status was associated with the proper reliability element number and encoded for processing by the Automated Reliability Assessment Programs (ARAP). Considerable coordination with NAFEC and contractor personnel was accomplished in order to insure the best possible accuracy of the above information.

DABS SENSOR/AUTOMATIC RADAR TERMINAL SYSTEM (ARTS) III PERFORMANCE COMPARISON.

DABS/ARTS comparison tests were made at NAFEC using real world targets of opportunity and controlled test aircraft. The primary purpose of these tests was to compare the DABS target reports from the sensor operating in the ATCRBS mode to the target reports from the ARTS; however, some tests were made with the DABS sensor operating in the DABS mode.

The method of testing was to simultaneously record data extraction tapes of real world targets of opportunity and controlled aircraft at both the DABS and ARTS sites. These data extraction tapes were then reduced to rho-theta plots and various program listings. All plots consisted of ATCRBS or DABS reports.

DATA COLLECTION.

The following paragraphs describe the methods used for extracting, reducing, and analyzing the data collected during the T&E.

DABS DATA EXTRACTION. The information collected included the track report data block, surveillance report data block, and the ATC report data block. The data blocks contain the following type of information: time of day, target ID, target ID confidence, altitude, altitude confidence, range, azimuth, range rate, azimuth rate, predicated range and azimuth, firmness, and radar flags to indicate if the report was radar reinforced, substituted, radar-only, etc.

ARIES DATA EXTRACTION. The information collected consisted of two types of data blocks: reply and radar. The reply data block contained the ARIES track number, target ID, altitude, range, azimuth, and ARIES time. The radar data block contained the ARIES track number and the range and azimuth of the target. In addition, the output tape had explanation codes for ARIES aircraft not responding to sensor interrogations.

There are limitations as to the amount of data that each of the above systems was capable of recording. The DABS extractor recorded a 50-aircraft scenario, including the asynchronous (fruit) replies and the target replies, if the fruit rate was 4,000 per second or less. The extractor recorded a 400-aircraft scenario excluding replies. The ARIES data extractor could record only a maximum of 50 aircraft with radar enabled.

DATA REDUCTION AND ANALYSIS (DR&A).

Several computer programs were developed at NAFEC to correlate the DABS data with the ARIES data. Since the inputs to the DABS sensor were known from the data recorded on the ARIES data extraction tape, sensor performance was characterized by a comparison of the two data tapes.

Five unique data reduction programs were written to analyze terminal sensor data in the following areas of sensor performance: (1) reports, (2) surveillance or tracking, (3) ATC reports, (4) radar, and (5) communications processing. Three similar programs were used to analyze sensor data in the following areas: (1) reports, (2) surveillance or tracking, and (3) communications processing. ATC reports and radar were not analyzed using an automated program since time of day was not available on the two formats during these tests.

The ARIES/DABS report analysis program compared DABS reports with those generated by ARIES. Since the ARIES tape contained only replies for each target, the program computed a report from the replies using a simple algorithm. In order to make a positive comparison between ARIES and DABS, a window was defined around the ARIES target having the following restrictions: (1) range difference of 0.03 nmi or less, (2) azimuth difference of 0.8° or less, and (3) a time difference of 0.15 seconds or less. Since the ARIES targets are input to the analysis program it was easy to determine, within the above window limits, which targets the sensor failed to detect. This performance parameter is the P_d, defined as the percent of the scans for which DABS declared a target divided by the number of scans when the target was actually present.

A second parameter analyzed was identity code reliability, which was the percent of scans, when DABS decoded the correct ATCRBS identity code, divided by the number of scans an identity code was received by the sensor. For this case, the DABS report data used must have fallen in the ARIES window for correlation. In a similar manner, the altitude code reliability was computed.

The last performance parameter analyzed for ATCRBS aircraft was the number of replies from which the report was generated. These data were recorded in the DABS report. For DABS aircraft, the average number of rollcall interrogations per scan was computed. Other statistics of interest output from the program are: (1) the number of extra sensor reports generated by DABS from either fruit or split reports, (2) the mean and standard deviation of the range difference between ARIES and DABS, and (3) the mean and standard deviation of the azimuth difference.

The program printed out error messages indicating where problems occurred that may have impacted the above statistics. In addition, the raw data for both the ARIES and DABS reports were output as an aid in further investigation. The program output summarized the above parameters for an independent set of scan numbers for each aircraft in the scenario.

After the data reduction programs summarized the performance parameter data for each aircraft, a subset of these data was selected to characterize sensor performance under various environmental parameters. This was accomplished for each of the scenarios.

The 42 aircraft in the basic scenario were categorized as follows: (1) clear-air or straight flight targets, (2) turning targets, (3) zenith cone or close-in targets, and (4) conflicting tracks. The scan numbers, at which the encounters took place for each aircraft in the above categories, were determined. Scan numbers for the clear-air targets were selected to provide a sufficiently large sample size. The scan numbers for the turning tracks were selected such that the data analyzed included the entire turn plus three scans after the turn. The zenith cone scans were selected to include six scans before and six scans after entering the zenith cone. For aircraft in a conflict (crossing or overturning) situation, only the scans of data within the actual conflict were analyzed. Two aircraft were considered to be in conflict if they were within 1.6 nmi and 2.4° of each other.

Table 1 identifies the track number, the scenario identity code, the assigned category, and the scans which were selected for each of the scenario aircraft.

TABLE 1. SCENARIO AIRCRAFT DATA

Category	ARIES Track Number	Scan Number
Clear Air	3	110-139
	39	5-54
	40	5-54
	41	5-54
	42	5-54
Zenith Cone	38	24-55
	6	40-121
	7	219-236
Conflicts	5	109-147
	15	109-147
	28	11-52
	29	11-52
	1	52-84
	2	52-84
	4	52-84
	19	52-63
	20	52-63
	33	23-34
	34	23-34
	35	23-34
	23	1-98
	24	1-98
	30	1-122
	31	1-122
	17	243-269
	18	243-269
	36	49-134
	37	49-134
	11	76-117
	12	76-117
	13	76-117
Turning Aircraft*	5	6-30
	6	12-36
	7	9-33
	8	12-36
	9	6-30
	10	15-39
	11	10-34
	12	25-75
	13	9-50
	14	12-36
	15	6-30

*A special scenario was developed for turning aircraft.

The capacity and real world data were analyzed by manual methods because of the large amount of target aircraft. For the capacity data, the basic 42-aircraft scenario was analyzed; for the real world, selected targets were analyzed.

TERMINAL TEST RESULTS AND ANALYSIS

SURVEILLANCE SIMULATION TESTS.

Data results are presented in graphs. The "X" axis (independent variable) represents 0, 4,000, and 44,000 fruit rates per second for ATCRBS, or 0, 50, and 200 fruit rate replies per second for DABS. In the mixed environment (DABS and ATCRBS targets) both the ATCRBS and DABS fruit rates were combined at each of the three levels. The "Y" axis (dependent variable) represents the performance parameter. For each performance parameter, a set of plots was generated. Seven parameters were selected: (1) P_d of ATC disseminated messages, (2) identity code reliability of ATC dissemenated messages, (3) altitude code reliability of ATC disseminated messages, (4) number of replies per report for ATCRBS targets, (5) number of interrogations per scan for DABS targets, and (6) b/s ratio. For each of the above plots both the 70 percent R/R data and the 93 percent R/R data are shown.

The signal strength plots display the RF signal level on the X axis. The Y axis represents one of the following four parameters: (1) P_d, (2) identity code reliability, (3) altitude code reliability, and (4) either number of replies per report or number of interrogations per scan.

The capacity scenario of 400 aircraft in 360° was reduced and compared to the basic 42-aircraft performance results determined from other scenarios.

Bar graphs were used to compare the data for the five aircraft categories with both the ATCRBS and DABS aircraft in a mixed environment. P_d, identity code reliability, altitude code reliability, number of replies per report, number of interrogations per scan, and the b/s ratio were compared to determine system performance under heavy aircraft loads. The capacity scenario of 282 aircraft in 90° was analyzed using manual reduction methods and the results were statistically compared to the basic scenario. For the capacity scenario, a group of 10 clear-air targets for 30 scans was selected and analyzed. Using bar graphs, the data for the parameters outlined above were calculated and compared with the clear-air targets in the basic scenario.

The short-term capacity scenario was analyzed manually. As indicated above, 10 clear-air aircraft, both DABS and ATCRBS, were selected for a total of 30 scans and analyzed. The same parameters were compared with data obtained from the basic scenario.

The real world test data were analyzed by manual methods. The performance parameters were computed and compared with basic scenarios under the same type of environment using both ATCRBS fruit rates of 0 and 4,000 per second, as well as R/R of 0.93 and 0.70. For comparison purposes, the real world data plots were superimposed on the basic plots of clear-air ATCRBS targets in a mixed environment.

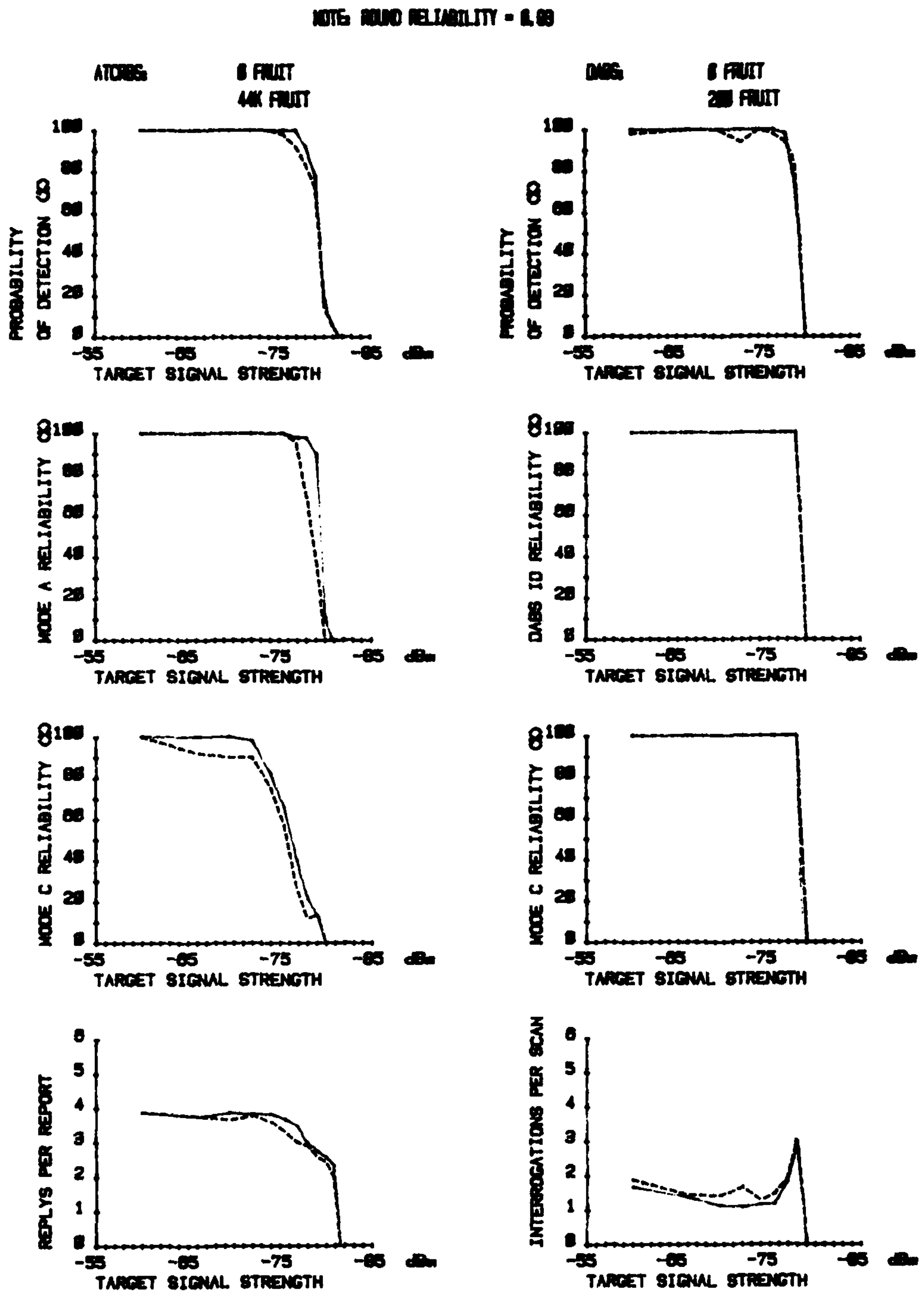
SENSOR PERFORMANCE VERSUS SIGNAL STRENGTH. Five of the terminal baseline tests used scenarios (one ATCRBS, one DABS) designed to characterize sensor performance as a function of RF signal strength. These scenarios are described in greater detail in appendix A.

In analyzing data from these tests, plots were formulated to depict sensor operation as a function of signal strength. These plots are shown in figure 4. Each of the five selected performance parameters is discussed in the following paragraphs. The data are plotted on the left side of the figure for ATCRBS targets in an ATCRBS fruit environment and on the right side for DABS targets with DABS fruit.

The P_d of ATCRBS targets was plotted for a 0 fruit and a 44,000 fruit per second environment. Detection was maintained at 100 percent until a signal level of -76 decibels above 1 milliwatt (dBm) was attained. Detection drops to 0 at -81 dBm.

P_d of DABS targets was plotted for two fruit rates, 0 and 200 main beam fruit per second. For the 0 fruit per second case, detection was 100 percent decreasing to a signal level of -76 dBm. Detection falls off sharply at -78 dBm. In the case where 200 DABS fruit per second were input along with the ARIES test signals, detection was virtually the same as the no fruit case, with the exception of two data points. The differences in the two DABS curves were attributed to the sample size analyzed. The detection for both DABS and ATCRBS was consistent with quantizer thresholds established for baseline testing. The P_d curves indicate a minimum usable signal level of -78 dBm. This is within 1 dB of the ER required -79 dBm. The additional dB of sensitivity may be achieved by adjusting the quantized sum ATCRBS (QΣA) and quantized sum DABS (QΣD) thresholds in the receiver.

Code reliability was defined to be the ratio of the number of times a correct code (mode A, mode C, or DABS ID) was detected to the number of times the target was detected. DABS targets maintained 100 percent code reliability (mode C and DABS ID) to signal levels of -78 dBm. ATCRBS targets showed different characteristics for mode A-code and mode C-code reliability. Mode A-code reliability was maintained at approximately 100 percent until a signal level of -78 dBm. Mode C-code reliability was 100 percent until a signal level of -73 dBm. At this point, the reliability fell off to approximately 60 percent at -75 dBm and less than 10 percent at -78 dBm. The reason for the difference was that ATCRBS mode A-codes might be corrected by the surveillance tracker, if target-to-track correlation was completed before the ATCRBS targets were extracted. An example of this would be an ATCRBS report with an incorrect code and associated low confidence bits. Once report-to-track



79-52-4

FIGURE 4. ATCRBS/DABS PERFORMANCE AS A FUNCTION OF SIGNAL STRENGTH

association took place, the report was tagged with the appropriate surveillance file number (SFN) and the code was corrected by a high confidence code from the tracker. Mode C-codes were changed from scan to scan and the tracker was not used to correct low confidence mode C-codes.

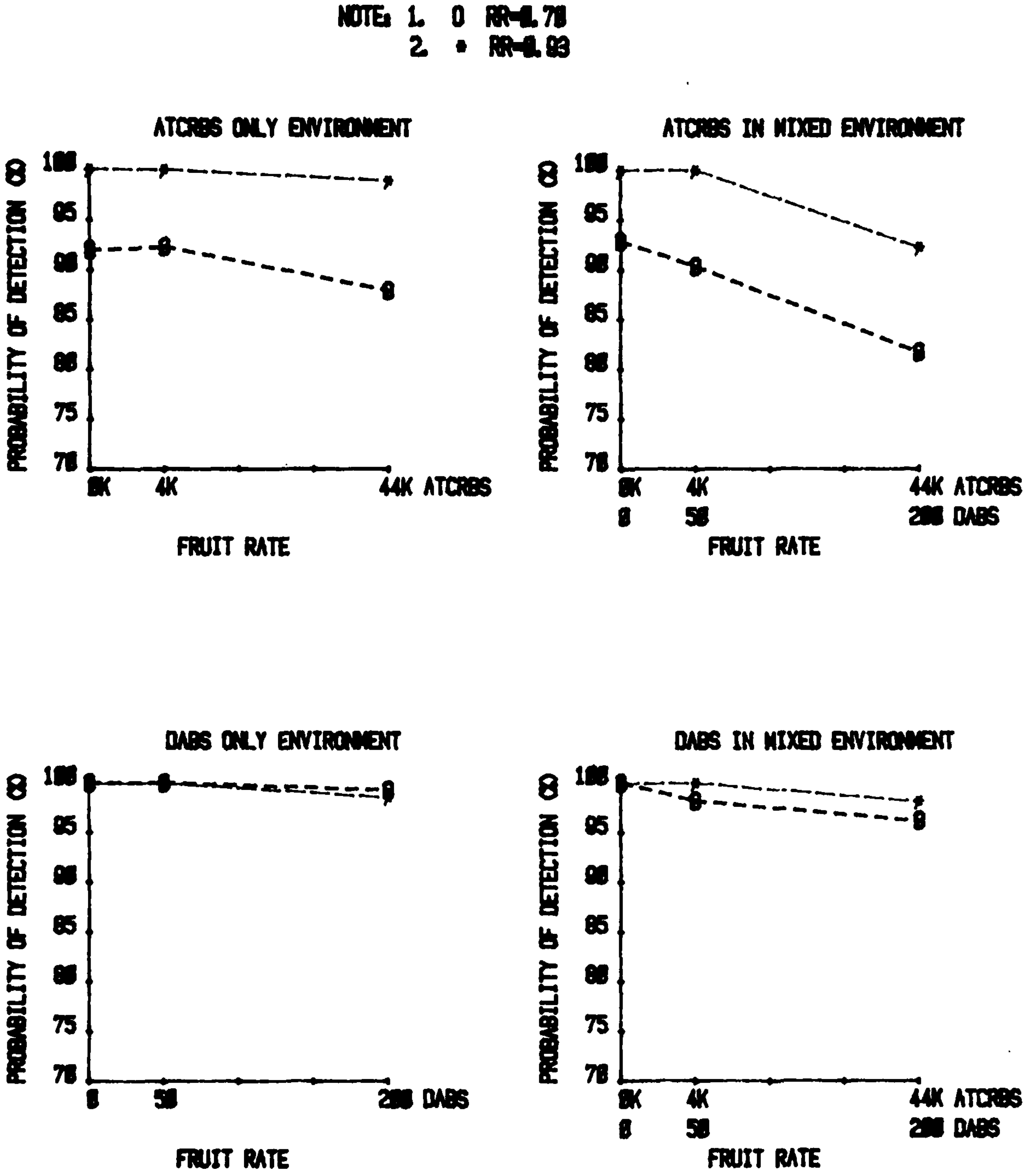
Although the DABS ER does not specify a required performance value for code reliability, both the ATCRBS mode A-code and the DABS ID are extremely good. The DABS altitude reliability is equally as good as its ID reliability. The ATCRBS mode C-code reliability is significantly lower than DABS, but comparable to the current ARTS III. This will be shown in subsequent sections of this report.

The pulse repetition frequency (PRF) of the ATCRBS mode was selected to provide four ATCRBS interrogations within the antenna 3 dB points. Figure 4 presents a maximum average number of replies per report as a function of signal strength. Since a reply probability of 0.93 was selected in ARIES, the number of replies per report expected was 3.72 (0.93 x 4). The graph shows that the expected results were attained; the number of replies per report was down to 3.0 at a signal level of -77 dBm and was always two or greater as single-hit reports were discarded by the sensor as currently adapted.

The number of DABS interrogations per scan versus signal strength is plotted in figure 4. The point of interest is that the interrogation rate rises sharply for very weak signals. Since the number of very weak targets within the sensor's coverage area is small, any increase in the rollcall interrogation rate, due to these targets, should be insignificant. More data will be presented for this parameter in subsequent sections of this report.

ANALYSIS OF BASIC TEST SCENARIO. The System Baseline Test Matrix, figure 2, details the tests that were conducted using the basic scenario for: (1) all ATCRBS targets with three ATCRBS fruit rates, (2) all DABS targets with three main beam DABS fruit rates, and (3) a mixture of ATCRBS and DABS targets with both ATCRBS and DABS fruit. The test results were analyzed to determine if system performance varied as a function of the mixture of target and fruit type. The results of the analysis are shown in figure 5, which depicts performance for clear-air ATCRBS and DABS targets in an independent and mixed environment. The plots indicate that P_d for DABS targets was not significantly affected by the addition of ATCRBS fruit and was independent of the target flight pattern. For clear-air ATCRBS targets in the presence of 200 fruit per second main beam DABS and 44,000 fruit per second ATCRBS, the P_d of ATCRBS targets was degraded by approximately 5 percent as compared to an ATCRBS-only environment.

The prebaseline test results indicate a minimal effect on ATCRBS mode A-code reliability, mode C-code reliability, or the number of replies per report as a result of high levels of DABS fruit. This was accurate for each class of target flight patterns. The system performance is, therefore, presented in an environment of DABS targets and fruit or ATCRBS targets and fruit.



79-52-5

FIGURE 5. PROBABILITY OF DETECTION OF CLEAR AIR TARGETS FOR ATCRBS/DABS TARGETS IN ATCRBS ONLY AND ATCRBS AND DABS MIXED FRUIT ENVIRONMENTS

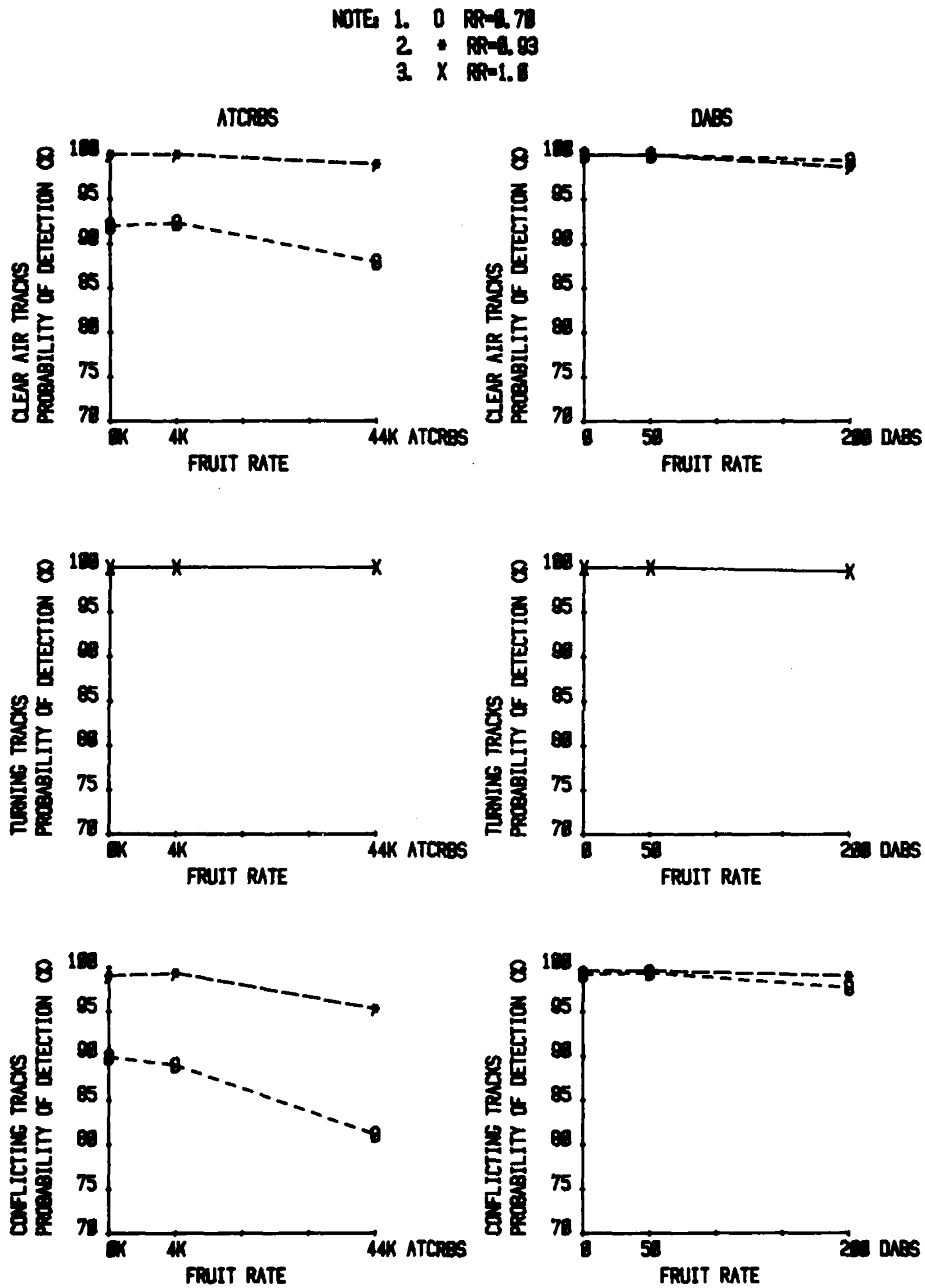
This effectively reduced the number of plots that showed little or no variation in system performance. All data collected have been plotted for analysis and are available at NAFEC. The test matrix defined duplicate test runs establishing the repeatability of test results. Test results for identical test conditions were combined to increase sample sizes for the various performance measures.

The description of the basic scenario test results were categorized as to the class of the target flight pattern and are presented as a function of fruit rates and round reliability. For ease of comparison, the performance achieved for ATCRBS and DABS is depicted side-by-side. The R/R for turning tracks has been plotted for a value of 1.0 due to the limitations of the scenario generator from which the turning scenario was derived. However, this is considered not to be a significant factor which will be evident as the results are addressed.

The test results for P_d are shown in figure 6. The plots indicate that for an R/R of 0.93 or greater, detection of ATCRBS targets decreased by a maximum of 4 percent for a fruit rate of 44,000 per second as compared to fruit rates of 4,000 per second or less.

The results also show that the loss in detection of ATCRBS targets for an R/R of 0.7, with a fruit rate of 44,000 per second had a maximum value of 8 percent. It should be noted that the maximum losses for values of 0.7 and 0.93 R/R was experienced for conflicting tracks. The degradation in ATCRBS detection between an R/R of 0.7 and 0.93 is attributed to the probability of receiving the required two replies out of a possible four replies in a beam width. Given that two replies are required to detect a target, the binomial function of discrete events computation indicates a statistical probability that 8 percent of the targets would not be detected. The test results also show that degradation in detection experienced for ATCRBS aircraft in conflict, as compared to clear-air performance, is insignificant for low fruit rates and an R/R greater than or equal to 0.93. Examining the detection performance for DABS targets, it is evident that DABS target detection was approximately 100 percent and independent of fruit rate, R/R, and aircraft flight pattern. This result occurred because DABS requires only one good reply, out of a possible four replies, per scan to achieve target detection. These results agree with the binomial function of discrete events, which indicates that the probability of generating less than one reply is less than 1 percent.

Figure 7 depicts the results of ATCRBS mode A-code reliability and DABS ID reliability. As the plots indicate, there is no significant difference in performance for the various fruit rates or the R/R employed for both the ATCRBS and DABS. It is apparent that if target detection is successful, then the probability of a resulting correct ATCRBS mode A-code, or a correct DABS ID, approaches a value of 1.0. This was expected for DABS since a DABS rollcall reply is not considered valid if its address does not agree with the expected address. The address comparison is performed following error



79-52-6

FIGURE 6. PROBABILITY OF DETECTION

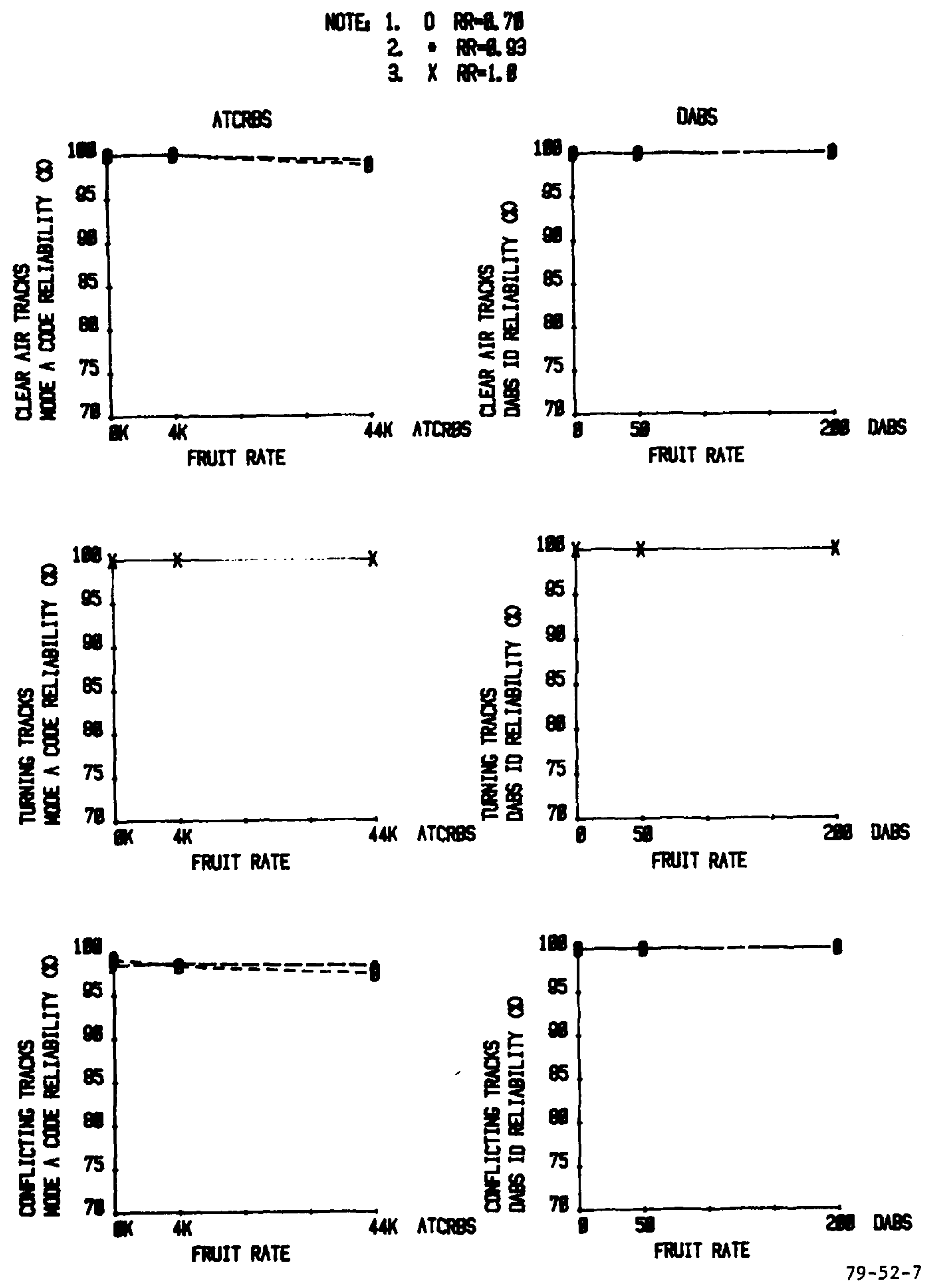


FIGURE 7. ATCRBS MODE A-CODE/DABS ID RELIABILITY

correction, if required. It should be noted that an invalid reply is not considered during the detection process. However, this is not true for an ATCRBS target. Detection can occur without regard to the mode A-code reliability.

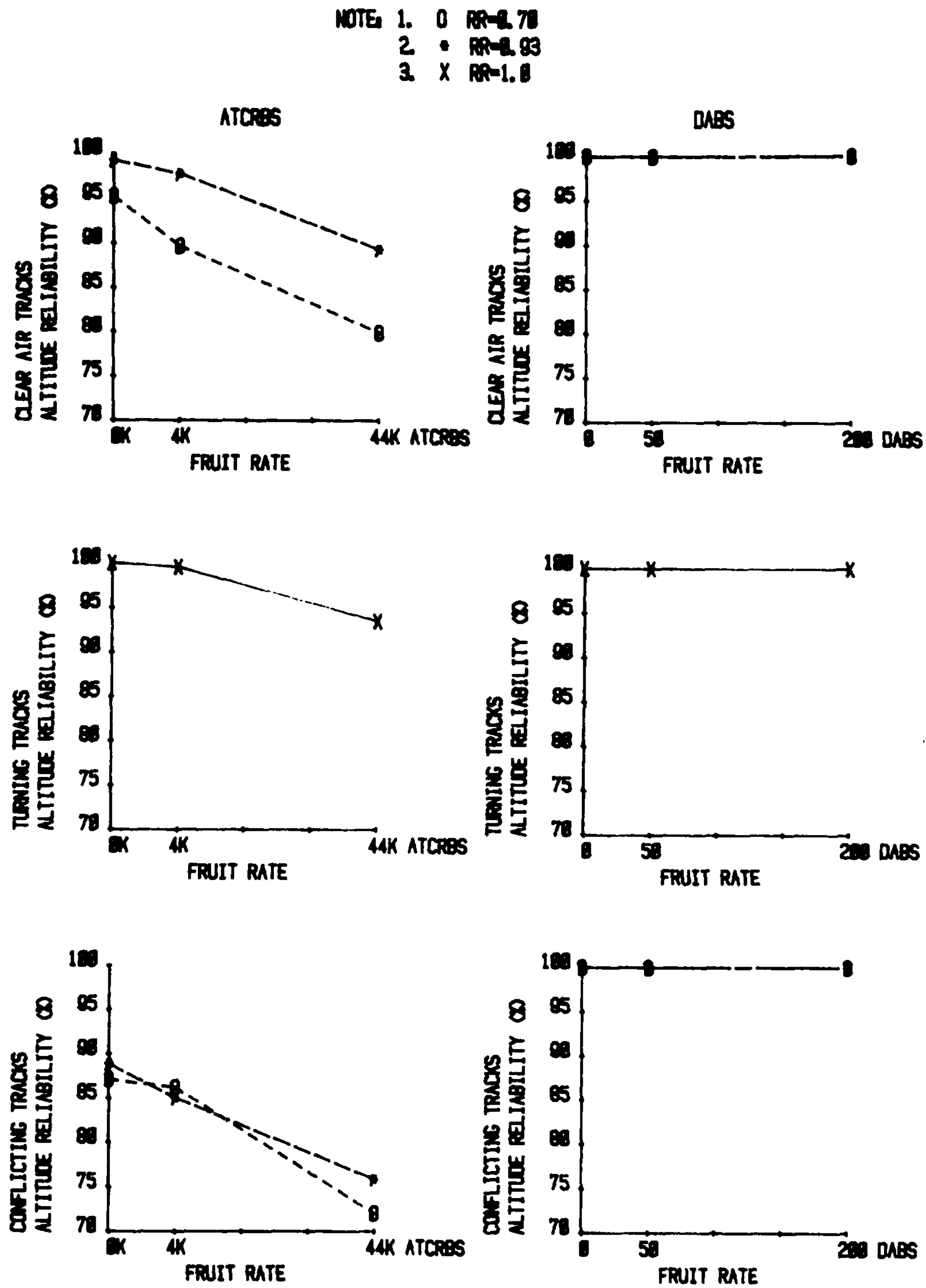
The altitude reliability results for ATCRBS and DABS are presented in figure 8. There is a similarity between trends in the results for ATCRBS percent detection and for ATCRBS altitude reliability (figures 6 and 8). Specifically, ATCRBS altitude reliability decreases with increasing fruit rates for all R/R for both clear-air tracks and conflicting target tracks. The degradation averages approximately 10 percent and is attributed to code information pulse garbling, due to fruit at the reply level.

In addition, if the effect of high fruit rates on clear-air ATCRBS altitude reliability is compared to the altitude reliability achieved for tracks in conflict in an environment with little or no fruit, it is evident that there is a similarity in performance. This was expected since the garbling of reply pulses experienced for crossing tracks has the same resultant affect of garbling due to high fruit rates. It should be noted that in order to achieve an indication of a valid (100 percent reliable) altitude, all pulses within the code train must have been high confidence. In addition, there is no feedback from the tracked data for target altitudes having low confidence as there is for the mode A-codes. The 5 to 8 percent decrease in altitude reliability for clear-air targets that was experienced for an R/R of 0.7, as compared to an R/R of 0.93, was attributed to the 5 percent of target reports declared using two mode A-code replies and no mode C-code replies. According to the binomial function of discrete events, approximately 4.4 percent of the reports generated should not contain altitude data.

The results for DABS indicate that altitude reliability was approximately 100 percent for all fruit rates, R/R, and aircraft flight patterns.

The average number of ATCRBS replies per report and the average number of interrogations per aircraft per scan are shown in figure 9. The pulse repetition rate for the ATCRBS mode of DABS was selected to assure a maximum average of 4.0 replies within the 3 dB points of the ATCRBS 5-foot antenna. This value was based on an R/R of 1.0. As can be seen from the graphs in figure 9, the ATCRBS data were not affected by different aircraft flight configurations, and only slightly affected by very high fruit rates. The replies per report decreasd by approximately 0.2 in the 44,000 fruit per second environment. There is a decrease in the reply count of approximately 0.8 caused by decreasing the R/R from 0.93 to 0.70. This is a simple mathematical relationship since at low R/R less replies are available to make up a report. This low level of R/R is not expected in the real world. However, if 0.7 R/R is encountered, the P_d will drop to an unacceptable level.

For DABS aircraft, the average number of interrogations per scan should be 1.0, assuming an R/R of 1.0, and no interrogations before the antenna beam illuminates the target. The DABS data were slightly affected by the very high fruit rates. The interrogation rate increased by approximately 0.1, and was



79-52-8

FIGURE 8. ALTITUDE RELIABILITY

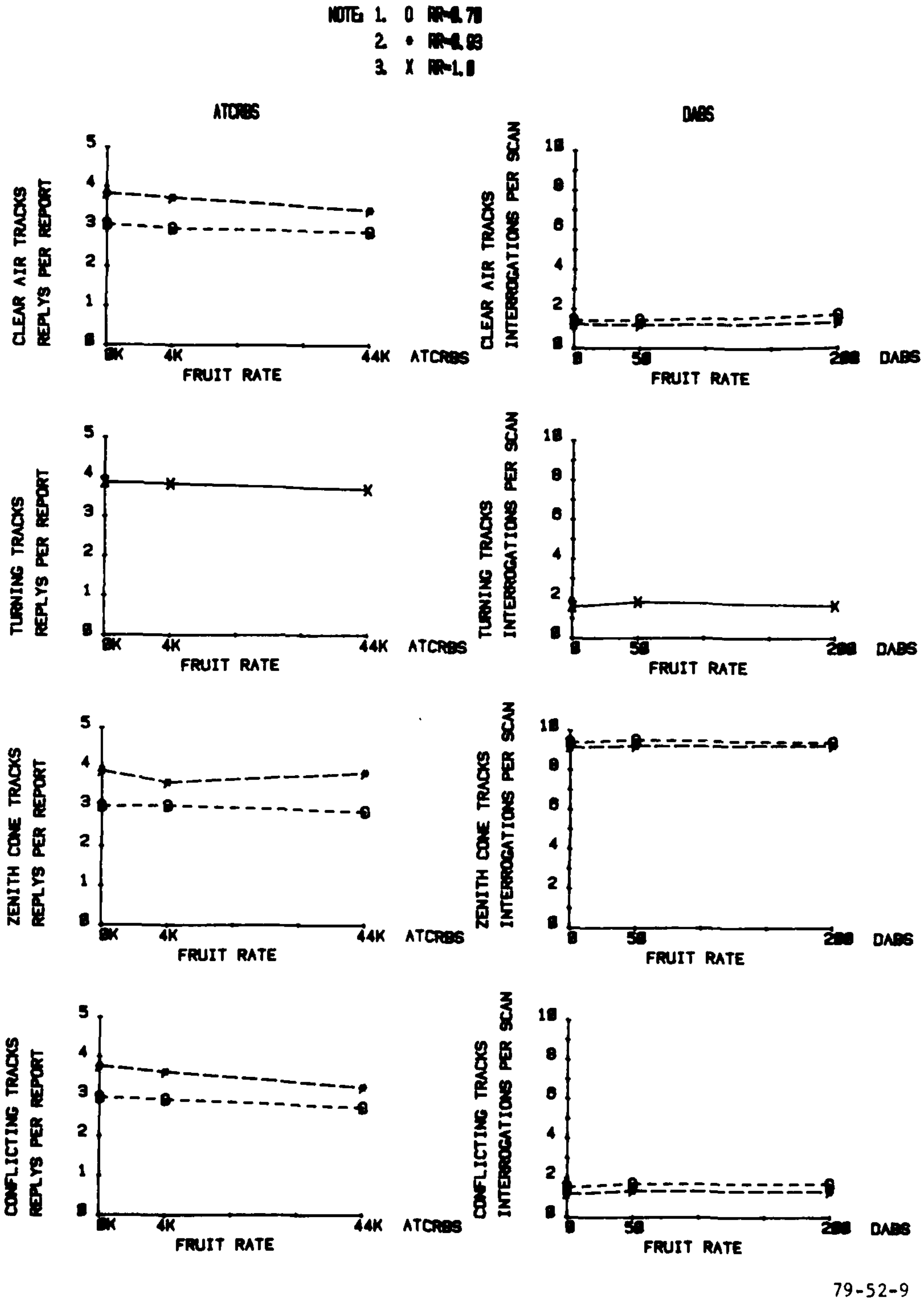


FIGURE 9. ATCRBS REPLIES/REPORT AND DABS INTERROGATION RATE

not affected by changes in aircraft flight configurations except for zenith cone tracks. It was evident that for zenith cone tracks an average increase of eight interrogations per scan was experienced. This phenomena is caused by the sensor continuing to interrogate the aircraft, up to 40 times per scan, even though the aircraft had entered the zenith cone. This continued for six scans until the aircraft track was dropped by the sensor. This will be explained in more detail under the system problem areas of the report. As in the ATCRBS case, the DABS data were affected by decreases in R/R since reinterrogations must be made if no reply data are received from the aircraft on the first interrogation. The interrogation rate increased from 1.3 to 1.5 due to the reduction in R/R from 0.93 to 0.7.

A decrease from four replies per report degraded the P_d performance of the ATCRBS mode of the DABS system. In the DABS system, additional interrogations for surveillance were used to insure a very high P_d ratio. The increase in interrogation rate was noted only because of the impact on channel occupancy.

The surveillance tracker b/s ratio for both DABS and ATCRBS aircraft is shown in figure 10. The data presented both transponder and simulated radar reports from ARIES to update aircraft tracks. For example, if no beacon report was received for an aircraft on a particular scan, then a radar report could be substituted. The probability of an aircraft receiving a radar report on any one scan was 0.80. Thus, comparing the b/s ratio data with the P_d data will show an increase of approximately 8 to 9 percent due to the addition of radar for 0.7 R/R data. The b/s ratio was not affected by fruit rates or aircraft flight configurations and was approximately 99 percent. A 3 percent decrease in b/s ratio resulted from the low R/R data. The DABS data on the other hand was not significantly affected by fruit rates, flight configurations, or R/R. The b/s ratio was approximately 100 percent.

The basic 42-aircraft scenario contained track encounters with various intersect angles and closing rates. The basic scenario with three standard fruit rates and radar b/s ratio of 0.8 was run in the all DABS, all ATCRBS, and the mixed DABS/ATCRBS mode. Results from the all DABS runs indicate no mutual interference between DABS rollcall targets. There were no track swaps detected during any of the DABS/DABS or DABS/ATCRBS conflicts. Evaluation of the ATCRBS-only tests indicated some track swapping had occurred. A track swap occurs when the report data on a specified surveillance file number or track is permanently associated (more than two scans) with a second surveillance file number or track. There were no track swaps between two discrete ATCRBS targets, or between a discrete and a nondiscrete ATCRBS target. All target swaps involved two nondiscrete ATCRBS targets. At 0.93 R/R the tests indicated that 1 in 12, or 8.3 percent, of the conflicts resulted in a track swap. The scenario descriptions are contained in appendix A. The nondiscrete ATCRBS conflict sets include: 701X, 702X, 703X,; U, W; 401X, 402X; and F, G, H. A track swap occurred between 401X and 402X during a conflict. These targets had nondiscrete identities of 1600 and 1700; both were flying at the same altitude. Three out of 12, or 25 percent, of the nondiscrete ATCRBS conflicts had track swaps when the R/R was reduced to 0.70. The results above indicate that the ATCRBS mode of the DABS sensor performed well under the stringent conditions for each of the conflicting geometries.

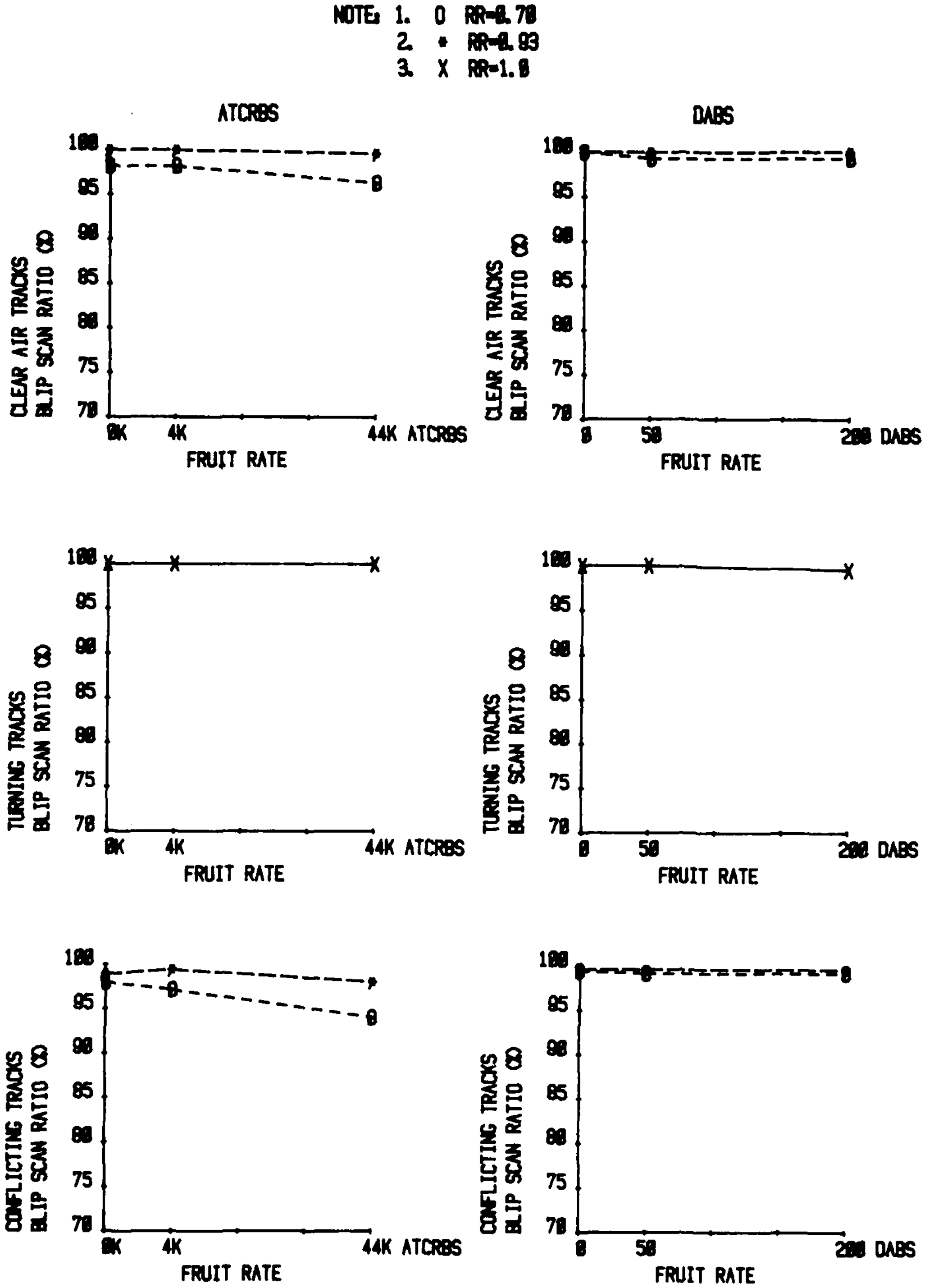


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FIGURE 10. SURVEILLANCE TRACKER BLIP SCAN RATIO

Figure 11 is a plot of the DABS short-term capacity performance. The 48 aircraft are DABS targets; Comm A messages were sent to every other DABS aircraft. Comm B messages were received from every tenth DABS aircraft. Each aircraft was separated in azimuth by 1/12° and all targets were clear-air and stationary in the wedge. The aircraft positions were separated by 1 nmi in a 4° wedge for a range of 60 nmi. The results indicate that the DABS P_d performance was also degraded significantly as compared to the basic 42-DABS scenario. Approximately one-half of the aircraft dropped out of the rollcall mode and into All-Call. In the All-Call mode, garbling decreased target detection. The P_d for DABS targets started dropping when approximately 37 DABS aircraft were on rollcall. Further investigation revealed that the channel management algorithm was not able to schedule all the targets in a DABS period. This problem is being investigated.

Two ARIES scenarios, 400 aircraft in 360° and 282 in 90° (1982 Los Angeles Basin model), were used to determine DABS sensor capacity performance. Figures 12 and 13 show the results of each scenario as compared to the basic 42-aircraft scenario. The 400 aircraft in 360° scenario were run with 44,000 fruit per second ATCRBS, 200 DABS fruit, an R/R of 0.93, and a radar reply probability of 0.8. The ATCRBS and DABS aircraft analyzed in each scenario were clear-air targets. As can be seen from the results on both ATCRBS and DABS tracks, there was no significant change in sensor performance observed between the 42 aircraft and the capacity scenarios.

The data for DABS interrogations per scan were not available from the capacity scenarios, figures 12 and 13, because of the heavy data recording load caused by trying to extract DABS replies.

The data in figure 13 (282 aircraft in 90°) were collected under the same conditions as 400 aircraft in 360° scenario, except the R/R was 1.0 and the radar reply probability was 0.2. The radar reply probability of 0.2 was used because of an ARIES capacity limitation. These changes did not have a significant effect on the results.

Again, as shown by the plots, there were no significant changes in sensor performance between the 42 aircraft to 400 aircraft scenarios. There was a minor change in ATCRBS P_d between the two scenarios which was expected at high ATCRBS fruit rates. The 282 aircraft in 90° scenario did have problems tracking nondiscrete ATCRBS aircraft. This is addressed in the SYSTEM PROBLEM AREAS section.

DABS/ARTS III SIMULATION. The plots shown in figure 14 are a comparison of DABS performance with simulated target inputs and ARTS III performance with simulated target inputs. Only ATCRBS clear-air discrete targets were used in the comparisons. The R/R for the DABS targets was 0.93, and the R/R for the ARTS III targets was 0.95. As can be seen from the plots for fruit rates up to 5,000 per second the DABS and the ARTS III displayed good performance (above 98 percent) for all three performance parameters: P_d, mode A-code reliability, and mode C-code reliability. At fruit rates of approximately 5,000 per second and above, the DABS performance was better then the ARTS III

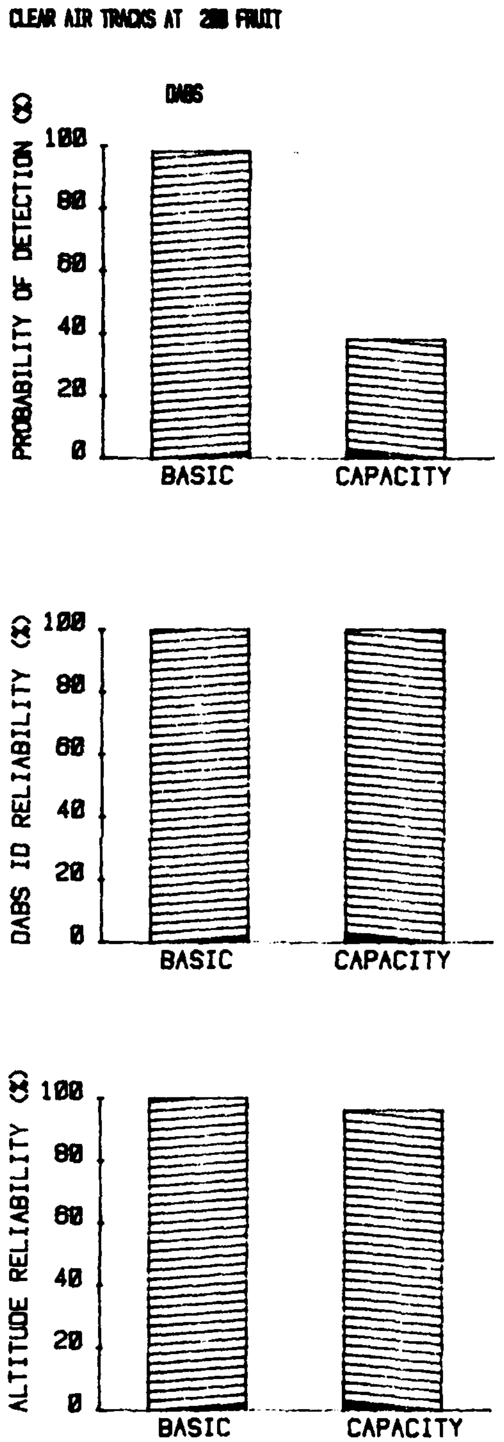

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FIGURE 11. DABS PERFORMANCE FOR A SHORT TERM CAPACITY OF 48 A/C IN 4 DEGREES

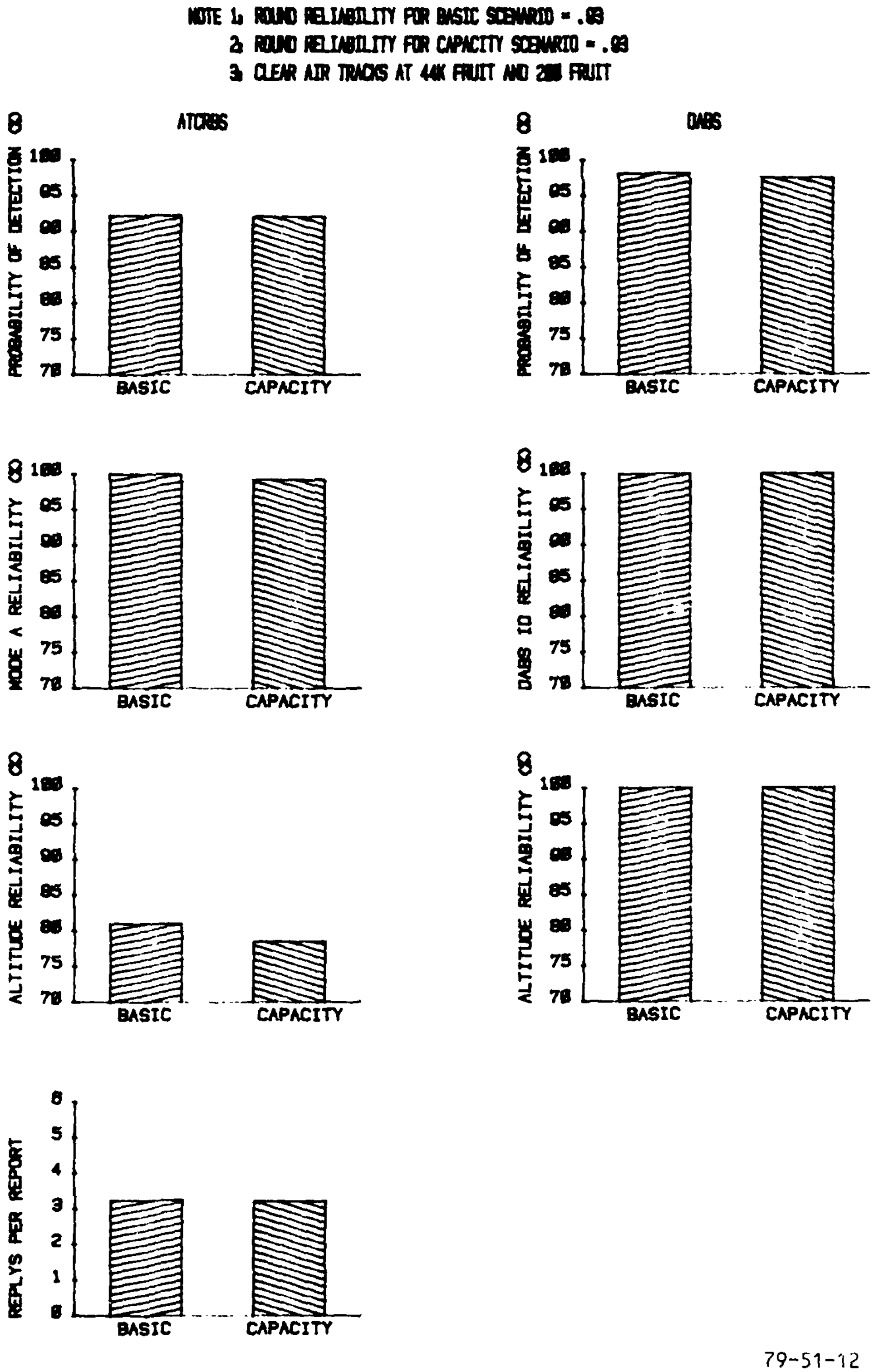

FIGURE 12. ATCRBS/DABS PERFORMANCE AS A FUNCTION OF CAPACITY (400 A/C IN 360 DEGREES)

NOTE 1: ROUND RELIABILITY FOR BASIC SCENARIO = .93
2: ROUND RELIABILITY FOR CAPACITY SCENARIO = 1.0
3: CLEAR AIR TRACKS AT 44K FRUIT AND 200 FRUIT

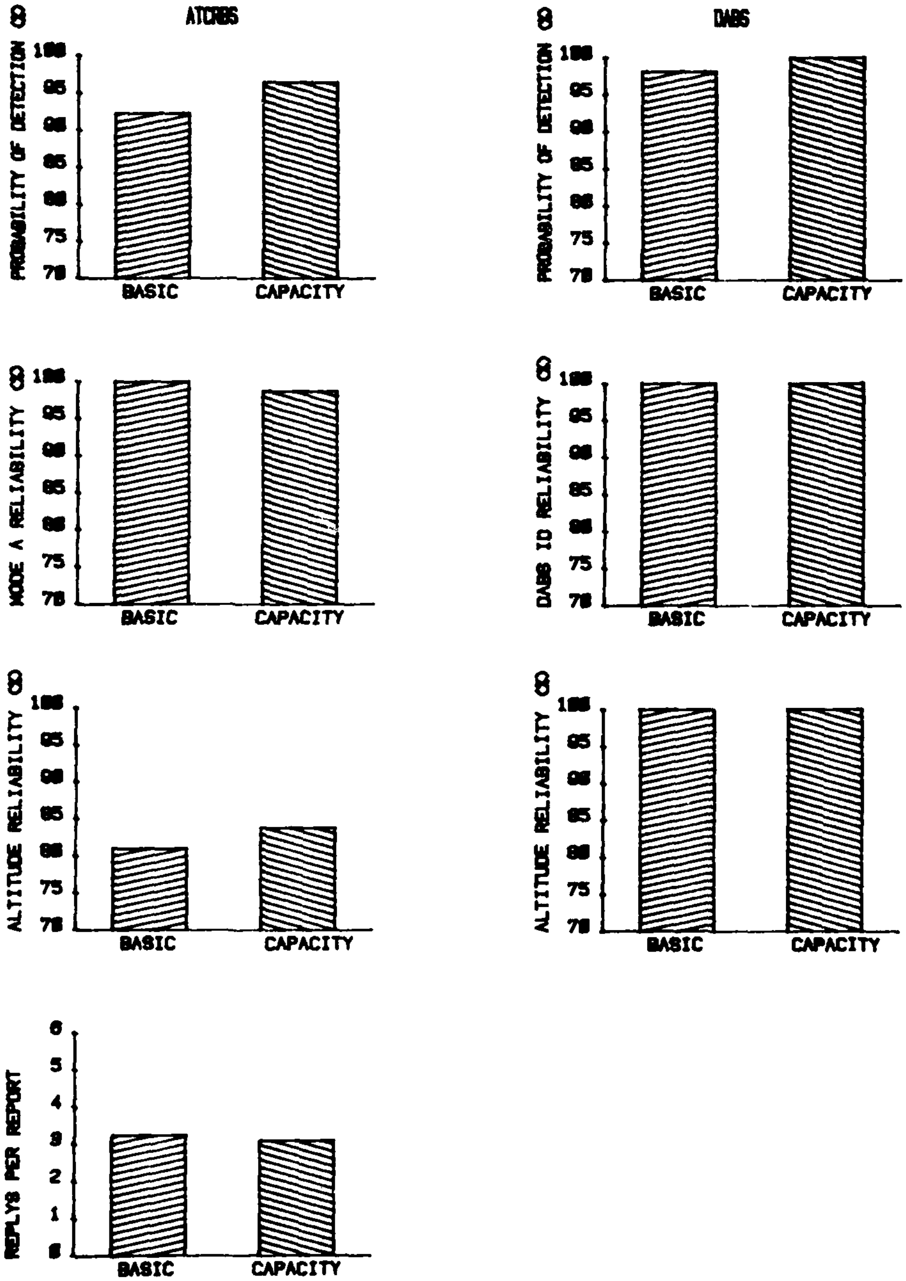

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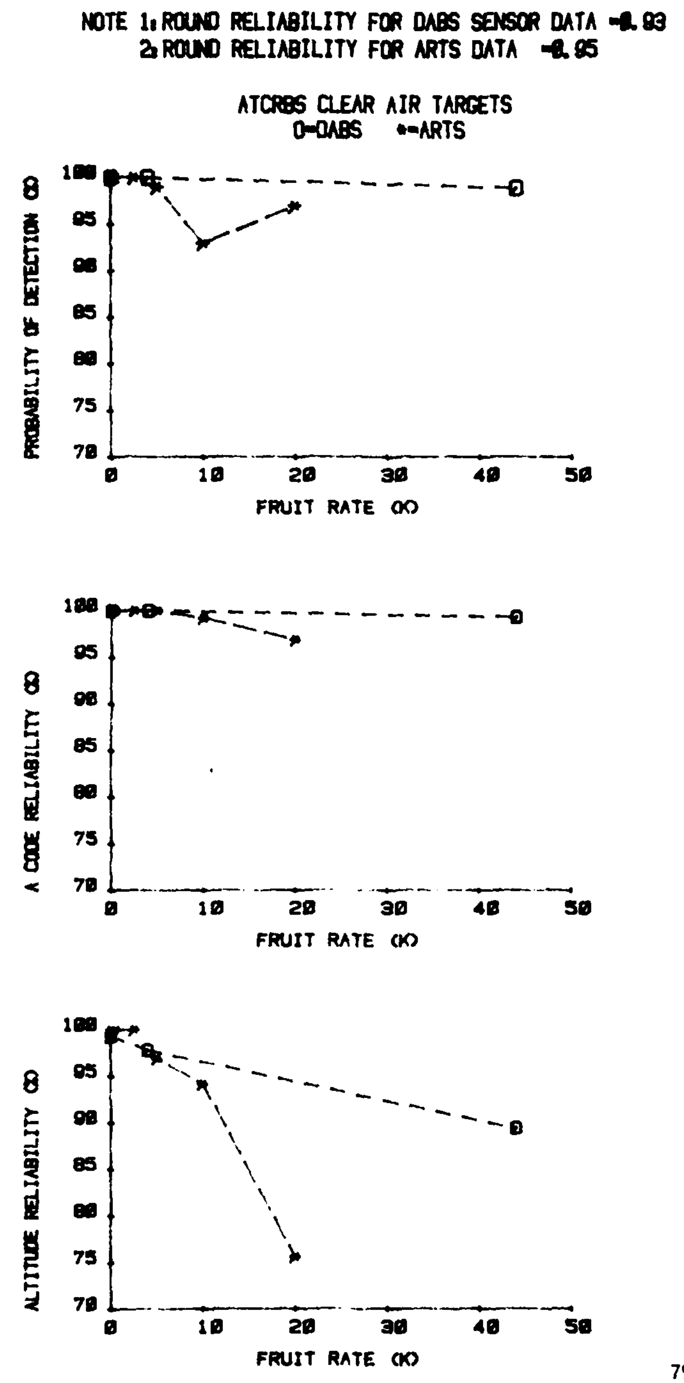
FIGURE 13. ATCRBS/DABS PERFORMANCE AS A FUNCTION OF CAPACITY (282 A/C IN 90 DEGREES)



79-52-14

FIGURE 14. DABS/ARTS PERFORMANCE AS A FUNCTION OF FRUIT UNDER SIMULATED INPUTS

system for each parameter. The DABS mode A-code employs tracker feedback and has an inherent code correcting mechanism. This correction feature was not employed for mode C-code. The test results indicated that, for fruit rates in excess of 10,000 per second, DABS altitude reliability was 20 percent better than ARTS III.

A split declares the presence of a false or extra report, or a report that declares a nonexistent aircraft. Figure 15 is a plot of the number of ATCRBS splits per scan. These values were obtained using the basic 42-aircraft scenario consisting of approximately 40 targets per scan. ATCRBS fruit was introduced as the independent variable. Both systems exhibit good immunity to fruit up to 2,500 per second. At fruit rates from 5,000 to 20,000 per second ARTS III performance degraded from two splits per scan to eight splits per scan. DABS sensor performance was not affected by high fruit rates.

ARIES SIMULATION VERIFICATION. Verification of the terminal surveillance simulation testing was performed by comparing data collected during NAFEC test flights with similar data extracted during basic scenario testing. The results for the flight tests were an average calculated by combining the data from two separate flights with a NAFEC aircraft. At altitudes between 7,000 and 8,000 feet and a velocity of 240 knots the aircraft flew portions of each flight with an ATCRBS transponder and then switched to a DABS transponder.

The data collected were divided into several different classes for comparison with the simulation results. Figure 16 shows an ARIES test aircraft comparison of P_d for the ATCRBS and the DABS data in straight-line flight and in turns. The data plotted for ARIES was taken from the basic scenario run with a 0.93 reply probability and 0 fruit per second. For the turning aircraft, the reply probability in ARIES was 1.0. P_d for straight-line flight targets was 100 percent for ARIES and the test aircraft in both the ATCRBS and DABS mode.

Turning aircraft detection values were less than straight-line detection values, especially for the test aircraft. The reason for this is that the ARIES data presented was run with the reply probability equal to 1.0, while in the real world flights, some reply loss was encountered because of antenna shielding. One of the test flights showed a much higher occurrence of antenna shielding than expected. At present, there is no explanation for the shielding; however, a large number of misses (reports and replies) were recorded during turns for one flight.

Figure 17 depicts mode A-code reliability and DABS ID reliability for ARIES and the test aircraft. In all cases the code reliability was 100 percent. Altitude reliability (figure 18) for the DABS target reliability was 100 percent for both ARIES and the test aircraft. ATCRBS altitude reliability was 5 to 8 percent less for the test aircraft than for ARIES. The probable reason for this difference is that the ARIES/ATCRBS targets averaged about 3.8 replies per report, while the test aircraft average 3.5 replies per report (figure 19). The discrepancy in the values may be due to a slight difference

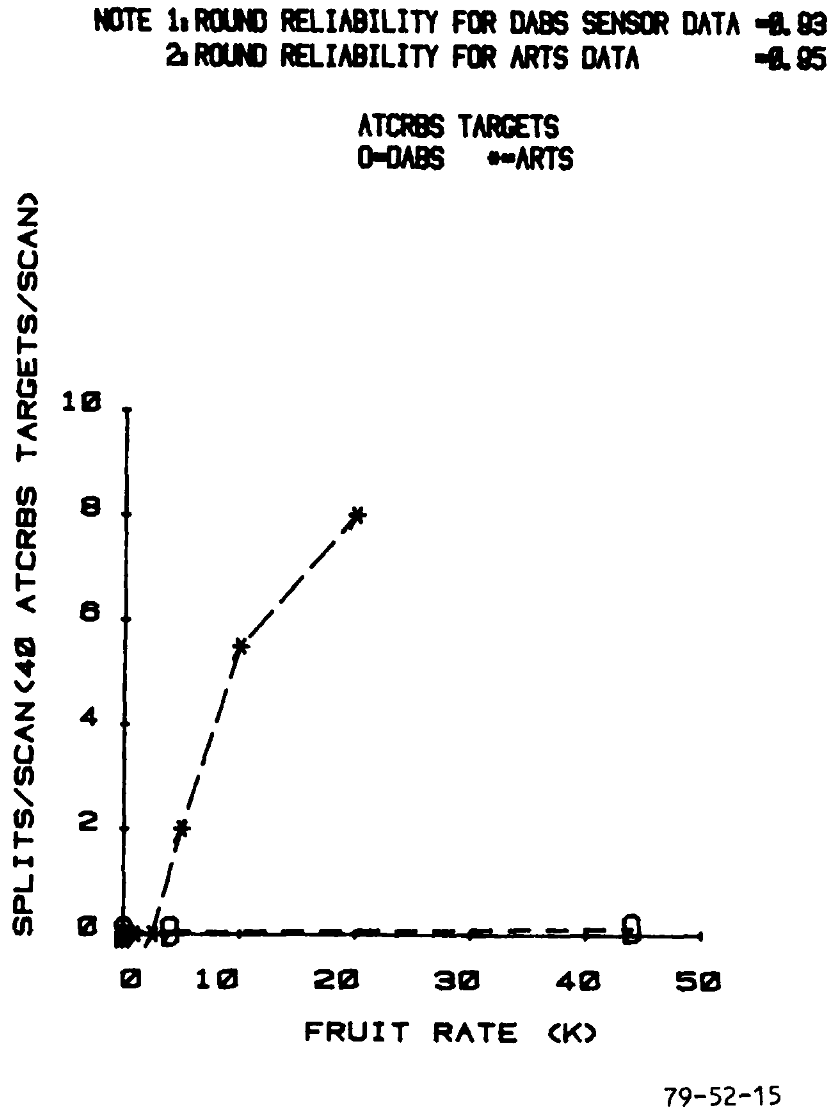


FIGURE 15. SIMULATED DABS/ARTS SPLIT PERFORMANCE AS A FUNCTION OF FRUIT

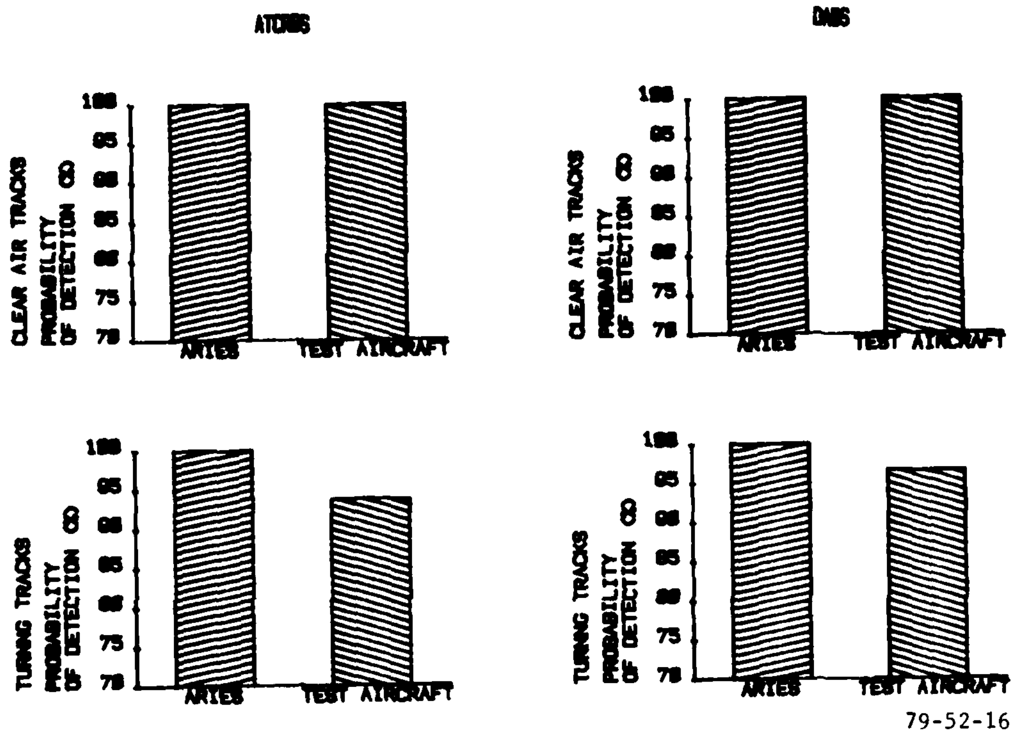


FIGURE 16. PROBABILITY OF DETECTION

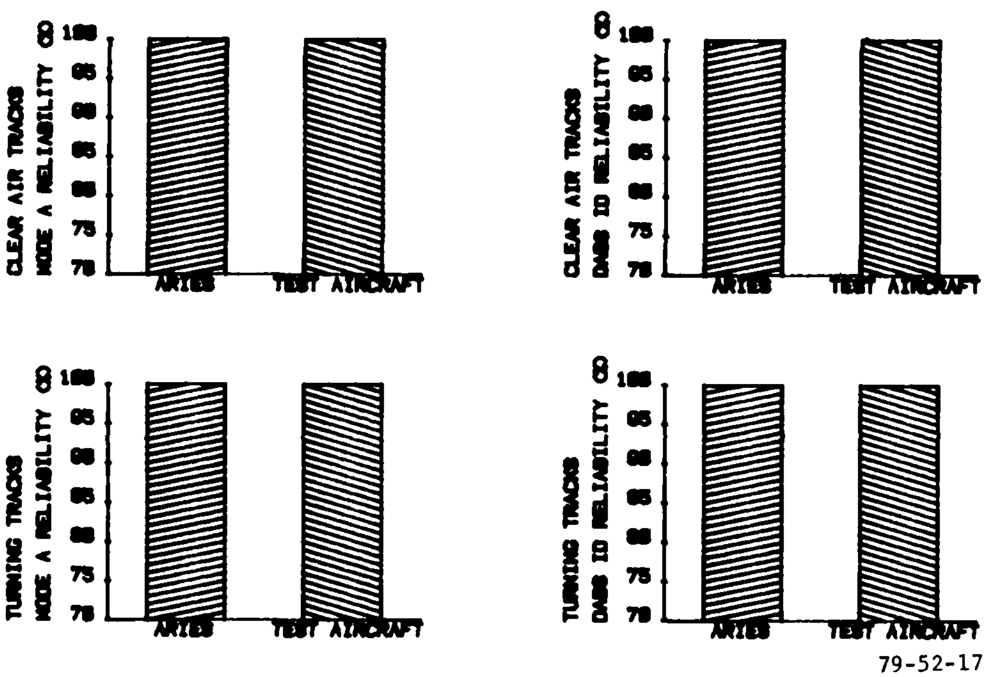


FIGURE 17. ATCRBS MODE A-CODE/DABS ID RELIABILITY

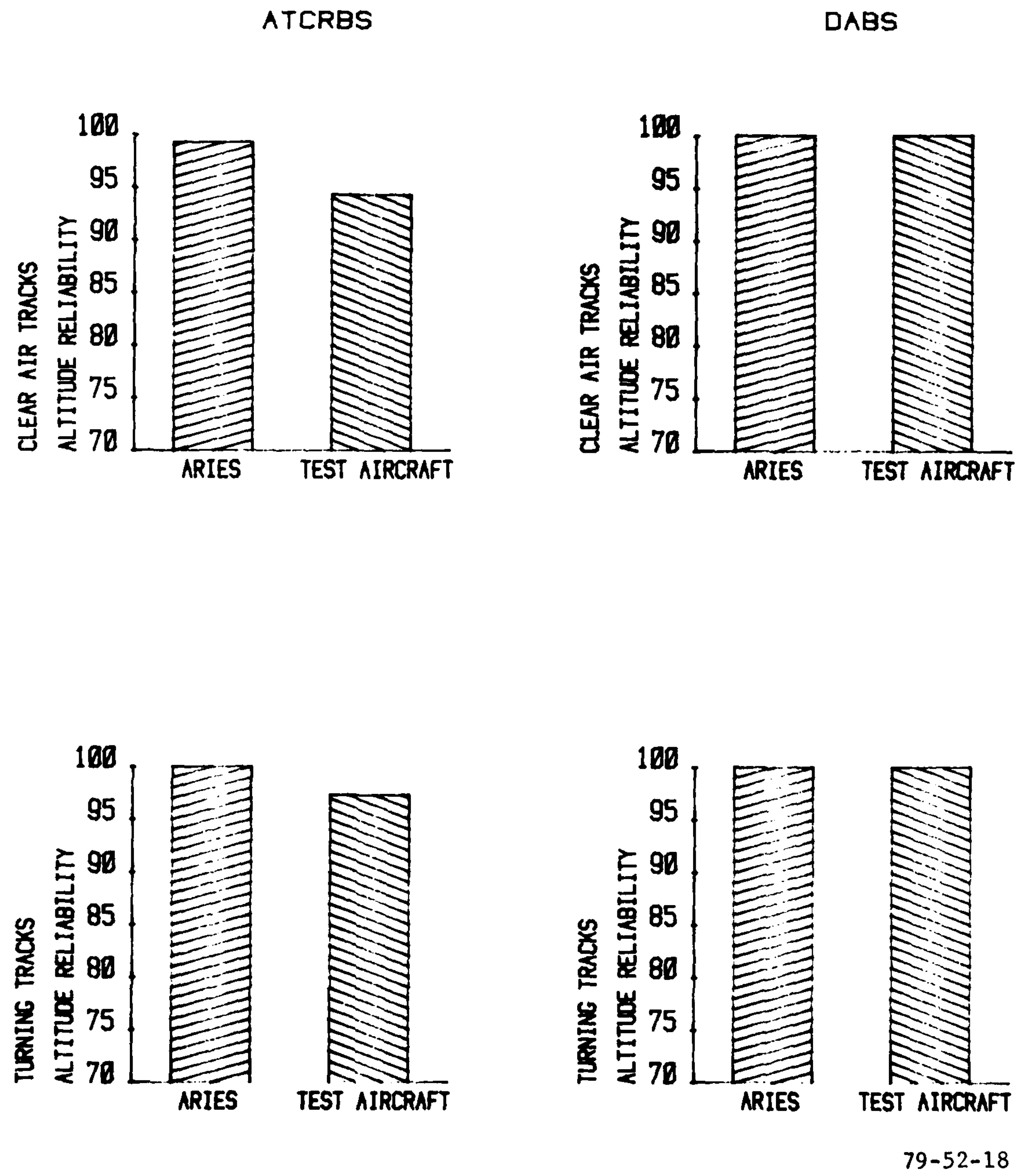


FIGURE 18. ATCRBS/DABS ALTITUDE RELIABILITY

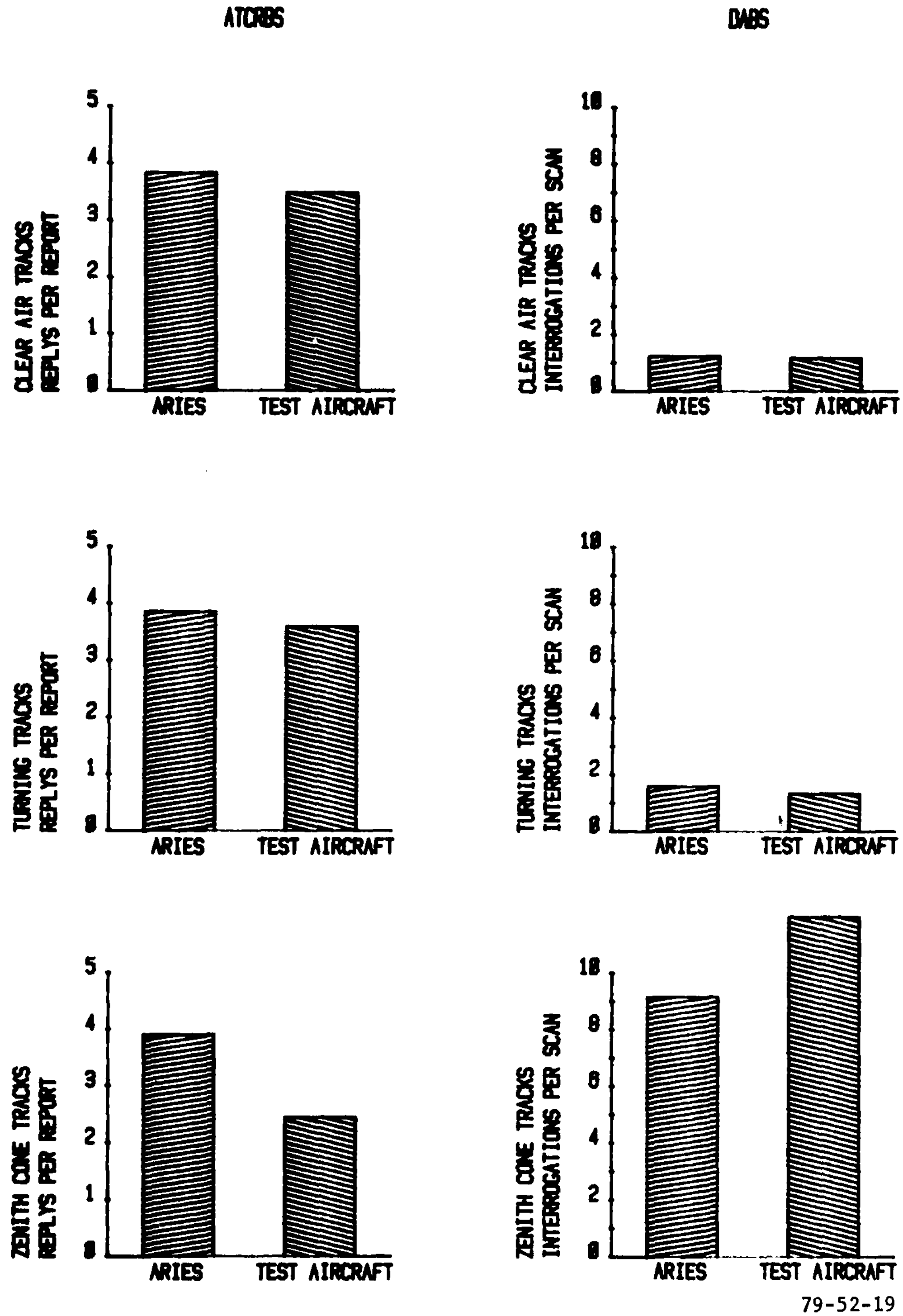


FIGURE 19. ATCRBS REPLIES PER REPORT/DABS INTERROGATIONS PER SCAN

between the antenna patterns as programmed in ARIES and the pattern of the ATCRBS 5-foot antenna. Since on the average, fewer replies were received from the test aircraft, the possibility of receiving a report with only one mode C-code reply was increased. If, for any reason, one of the 12 confidence bits is not set high in the mode C-code reply, an ATC report is built with the altitude confidence bit set low. This restrictive requirement leads to a reduction in altitude reliability for ATCRBS targets.

One of the graphs in figure 19 compares the number of replies per report for ATCRBS targets just prior to entering or leaving the sensor's zenith cone. ARIES maintains the same average replies per report near the zenith cone as it maintains in the clear-air. The test aircraft, however, averages only 2.4 replies per report when entering or exiting the zenith cone. This reduction is caused by marginal antenna coverage at high elevation angles. This reduction in reply probability at high elevation angles is not part of the ARIES simulation logic. Therefore, any of the ARIES simulation results for events at high elevation angles or near the sensor's zenith cone may be better than what is achievable in the real world.

The number of interrogations per scan for DABS targets entering or exiting the zenith cone is also compared in figure 19. The ARIES and test aircraft differ because the test aircraft was flown at a different altitude than the ARIES aircraft. Altitude is one of the variables used in the sensor zenith cone prediction equations. The important result identified in this graph is, that for both ARIES and the test aircraft, the number of interrogations for targets entering the zenith cone is excessive.

SYSTEM PROBLEM AREAS. During the DABS sensor baseline testing several major problems were encountered. There were three aircraft in the basic 42-aircraft scenario; ARIES track numbers 26, 27, and 28, flew west to east, approximately 40 nmi south of the sensor. These targets were 1.0 nmi apart and flew parallel flight routes. When these targets were DABS aircraft and first appeared in the scenario, the All-Call replies were not decoded by the DABS sensor, because the replies overlapped and garbled each other. During some runs of this scenario the garbling continued during the entire 100 scans; the P_d for these targets was significantly below the expected value. The garbling was caused by the long reply length in the DABS All-Call replies of 64 μs which is equivalent to a distance of approximately 5.2 nmi. Since the aircraft were only spaced 1 nmi apart, garbling took place. This occurred when two or more DABS targets "popped up" in proximity in the All-Call mode; no overlapping occurred in the DABS rollcall mode. Because of this problem, these aircraft were not included in the overall baseline results, but were treated separately. This problem has been identified by Lincoln Laboratory and solutions are being tested. One possibility is to have the sensor assign to a DABS transponder a specific reply probability, preventing a reply to every All-Call interrogation.

The ER specifies that a nominal value of two retries be used during each DABS period when a DABS target fails to reply. This means that if a DABS target does not respond to the first DABS rollcall interrogation, then two more interrogations are tried during the same DABS period. This requirement has not been met. Under most circumstances only one interrogation per aircraft can be transmitted during a DABS period. Thus, a maximum of four interrogations can be sent to one DABS aircraft instead of a possible 12 interrogations during one antenna scan. The lower interrogation rate is attributable to: (1) the fact that it takes a finite amount of time to schedule all the aircraft and get the commands to the transmitter, (2) channel management must stop short of the end of the DABS period in order not to overlap the periodic ATCRBS/DABS All-Call interrogation, and (3) the beam width of the sensor antenna was 2.4° instead of the original 4.0° which shortens the length of the DABS period proportionately. This problem is now being studied by both TI and Lincoln Laboratory in order to achieve the best possible solution.

There are two problems related to the zenith cone: (1) the DABS interrogation rate per scan, and (2) the ATCRBS tracks continuing through the zenith cone. The first problem was that the number of interrogations for a DABS target in the zenith cone varied from approximately 100 to 180, depending on the altitude of the aircraft. This was a result of scheduled interrogations during the period for which the track was in coast prior to track drop from the surveillance file. In order to drop a track, six consecutive scans of receiving no data must take place. These overinterrogations can be avoided with equations that can be implemented in the surveillance software to determine if a DABS aircraft is entering the zenith cone. The ER has been corrected to specify that a DABS track be dropped in the zenith cone.

The second problem was concerned with ATCRBS tracks being continued through the zenith cone. When an ATCRBS target transitioned through the zenith cone, the area box around the predicted postion of the aircraft expanded causing a miscalculation of target position. This caused the target position to vary erratically in the zenith cone. When the target emerged from the cone, the DABS sensor generally started a new track on the aircraft because the predicted position no longer correlated to the actual position. In either case, a change in track number (surveillance file number) will create problems with the terminal ATC software tracking algorithms (TAB-G tracker) which results in a loss of track continuity. Under these circumstances, it would be advantageous to drop the track when the aircraft enters the zenith cone and start a new track on the aircraft when it emerges from the cone. This recommendation has been incorporated into the ER. This does not apply to tracks being maintained as external data.

During capacity scenario testing of 282 aircraft in 90° and 60-nmi range, some nondiscrete ATCRBS targets were not tracked, or changed track numbers repeatedly. This was caused by the bunching of nondiscrete ATCRBS aircraft in wedges. When this occurred, the surveillance target-to-track software was not able to keep up with the number of targets in the scenario. As a result, many target reports were not correlated with track numbers. This will cause problems with the terminal ARTS III since they only received tracked reports and not uncorrelated reports. This problem is under investigation by TI.

DETAILED ANALYSIS. As part of the test and evaluation process, several test runs were analyzed in great detail. The DABS/ARIES Automated Analysis Program was used extensively throughout the baseline testing to automatically aid in the determination of basic test results and conclusions. However, this program was not intended to be used for more detailed problem detection or lower level analysis. Hence, detailed analysis of selected tests was performed and problem areas have been identified and investigated. The detailed analysis procedure consisted of tracking each aircraft through the entire 300 scan test run and looking for anomalies at all levels of system operations. This included analysis at the reply, report, surveillance file, and the ATC disseminated message levels. In addition, some information was obtained by examining data from the analysis summaries of the Automated Analysis Program. Detailed information came from tracing through the error message listings generated when there was a difference between the target generated by the scenario and the target generated by the sensor. The scenario selected for the detailed analysis was the basic 42-aircraft scenario with an R/R of 0.70 and 0 fruit per second, test runs 29, 30, and 31 (figure 2); and the scenarios with high fruit, test runs 35, 36, and 37 (figure 2). The affect of fruit on system performance was a prime consideration. Items or problem areas of significant magnitude are presented below for each of the selected test runs.

Test run 29 was a basic 42-aircraft scenario consisting of all ATCRBS targets in a 0 fruit per second environment and an R/R of 0.70. This scenario was used to verify the performance of the sensor in the ATCRBS mode in a 0 fruit per second environment. It was determined that the algorithm to replace the mode A-code in target reports with the mode A-code from the surveillance file did not meet the ER specifications. Degradation of mode A-code reliability in the baseline testing was a direct result of this problem. A system change notice (SCN) has been issued to modify the incorrect coding.

During the later part of the test run there was a period in which most ATC messages were disseminated twice. This appears to be a timing problem between the surveillance tracker and data dissemination function and is being investigated.

Test run 35 was a basic 42-aircraft scenario consisting of all ATCRBS targets with 44,000 fruit per second and an R/R of 0.70. This scenario was used to verify the performance of the sensor in the ATCRBS mode with a high fruit rate. A detailed analysis of this test run disclosed no additional problem areas.

Test run 30 was a basic 42-aircraft scenario consisting of all DABS targets in a 0 fruit per second environment with an R/R of 0.70. Analysis indicated that no additional problems were encountered.

Test run 36 was a basic 42-aircraft scenario consisting of all DABS targets with 200 DABS fruit per second and an R/R of 0.70. The detailed analysis provided no additional problem areas.

Tests runs 31 and 37 were basic 42-aircraft scenarios consisting of mixed DABS and ATCRBS targets with 0 and 44,000 fruit per second and ATCRBS/200 DABS fruit per second and an R/R of 0.70. The detailed analysis of these test runs revealed little or no interaction or interference between the ATCRBS and DABS targets. The detailed analysis conducted on the above test scenarios uncovered minor problem areas which were not detected during baseline testing. However, most of these problems have already been resolved or are being investigated. There were no major problems detected which would affect overall system performance or require major software and/or hardware changes. The detailed analysis verified that the test results obtained by employing the DABS/ARIES Automated Analysis Program were valid.

FAILURE/RECOVERY TESTS.

All of the failure/recovery tests were conducted using the basic 42-aircraft mixed scenario. This scenario provided a beacon R/R of 93 percent and a radar b/s of 0.80. The ATCRBS fruit rate was set at 4,000 replies per second, and a DABS fruit rate of 50 replies per second was employed.

A first attempt at running the failure/recovery tests uncovered several problems which required a new sensor load tape to be generated with the appropriate fixes. These problems are summarized below:

1. A spare computer had a bad local memory board.

2. A voted computer residing in the same ensemble as failure/recovery (SSOOAX) was not properly handled.

3. Modifying the task assignment table during sensor startup did not cause the intended configuration to be properly downloaded.

4. Failure/recovery design includes a hierarchy of failure/recovery responsibilities to handle ensemble failures when the bad ensemble contains failure/recovery, primary standby, and other spares (this assumption of responsibility by lesser spares was not carried beyond the first spare).

5. Failure of the primary standby caused the sensor to falsely sense that there were no spare computers to handle the failure. As a result, the sensor would shut itself down.

It was also discovered that the current system implementation restricts failure/recovery, performance monitor, or primary standby from residing on the ATCRBS or Comm Tilines. When remaining spare computers resided only on these Tilines, at the time one of the above tasks failed, the sensor shuts itself down. This limitation required the order of the computer failures to be adjusted to failure/recovery, performance monitor, and primary standby, only when there are spare computers available in main ensembles 1 through 7. Because of the order in which computers within a failed ensemble are assigned to spare computers, the performance monitor and primary standby computers were placed first in their respective ensembles when that ensemble failed. Otherwise the above mentioned limitation would have been encountered.

An analysis program was prepared to provide a table containing each track number within the surveillance file and the track firmness assigned for each scan that the track prevailed. The time at which a specific component failed is also indicated. Table 2 depicts the track performance achieved in the absence of any component failures. Occasionally, data extraction is loaded down by collecting ATCRBS replies and is slowed down in collecting surveillance file entries. This causes surveillance file entries for two separate scans to have the same scan number attached to them. This phenomenon can be seen as spurious dashes as in tracks 8 and 9. Also, it should be noted that there are several tracks that drop prior to the last scan of the test run. This is attributed to the structure of the test scenario.

Track firmness for each of the eight failure conditions tested are presented in tables 3 through 10. The specific components failed are identified in each table, along with an indication of the scan for which the failure was envoked.

The first failure condition as shown in table 3 verifies that the DABS sensor controlled the failures without any problems. The sensor did not lose track of any aircraft during the entire test. The ensemble failure caused the sensor to "coast" 9 targets for one scan and the remaining 23 targets for two scans. The global memory failure did not disrupt the sensor's operation. The modem failure had no affect on tracking aircraft; data extraction continued collecting surveillance target reports normally without interruption.

In the next test (table 4), the DABS sensor kept the original track file numbers for all but one target throughout the sequence of failures. Surveillance file entry 1 was dropped after the second computer failure and reinitiated as surveillance file entry 40. The aircraft was ATCRBS with its 4096 code set to 1200.

The first computer failure (beacon scheduling) caused 23 tracks to coast for one scan and the remaining 9 tracks to coast for two scans. The second computer failure caused 28 tracks to coast for two scans, 2 tracks coasted for three scans, and 1 track remained solid. The third computer failure caused data extraction to halt collection of surveillance file information for 24 of 32 tracks. Aside from four tracks in the process of being dropped, this failure caused all but two tracks to coast for two scans. The fourth computer failure disrupted data extraction as did the third. Generally, all but three tracks were coasted for one scan. The memory and modem failures proved to be successful.

The DABS sensor kept the original track file numbers on all but four ATCRBS targets during the failure sequence in test 3 as depicted in table 5. The first computer failure (ATCRBS reply-to-reply correlation) caused one of the 32 active tracks to be reinitiated as a new track, 2 other short-lived tracks were initiated falsely for existing tracks in the process of being dropped. Tracks 5 and 21 caused short-lived tracks 38 and 39, respectively. Track 21 was reinitiated as track 37 (ATCRBS 4096 code = 1200, aircraft in conflict). The fourth computer failure caused track 1 to be reinitiated as track 42 (ATCRBS 4096 code = 1200).

TABLE 2. TRACK PERFORMANCE IN THE ABSENCE OF FAILURES

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 61 71 81 91 101 111
1	A---1200	10B4	0046	00B0	1111111111111111111111111111111111111111111111111111111111111111111111
2	A---4215	33C4	0784	0096	1111111111111111111111111111111111111111111111111111111111111111111111
3	A---1700	086A	0B5D	0069	111111111111111234566---
4	A---6754	26E4	1284	0096	1111111111111111111111111111111111111111111111111111111111111111111111
5	A---1743	1ED8	1608	00C8	6---
6	A---1600	1BB0	1D40	0096	11111111111111111111111111111234566-----------------------------------
7	A---1700	2364	1DDE	0096	11111111111111111111111111111234566-----------------------------------
8	A---4026	23D2	2178	0086	11111111111111111111111111111111111111111-11111-1111-1111111-1111-1111
9	A---2200	26F4	2231	008C	111111111111111111111111111111111111111111-111-1-1-11-1111111-11111111
10	A---5474	232A	2462	0064	1111111111111111111111111111111111111111111111111111111111111111123456
11	A---5271	2232	2487	0050	1111111111111111111111111111111111111111111111111111111111111111123456
12	A---1200	326E	2964	0078	1111111111111111111111111111111111111111111111111111111111111111111111
13	A---1200	31BA	2994	0078	1111111111111111112111111111111111111111111111111111111111111111111111
14	A---2525	2956	2C49	0040	1111111111111111111111111111111111111111111111111111111111111111123456
15	A---1700	0402	319A	0064	11111111111111234566--
16	A---7465	26FC	32B7	0096	1111111111111111111111111111111111111111111111111111111111111111111111
17	A---1700	0970	3373	0000	11111111111111234566--
18	A---1743	1E8A	3477	00C8	66--
19	A---1100	13DE	3516	012C	1111111111111111111111111111111111111111111111111111111111111111111111
20	D-000025	2D70	39EE	0000	1111111111111111111111111111111111111111111111111111111111111111111111
21	A---4111	0B52	3A5C	012C	1111111111111111111111111111111111111111111111111111111111111111111111
22	A---1252	32B0	3C90	012C	1111111111111111111111111111111111111111111111111111111111111111111111
23	A---1752	1362	3F44	0064	--
24	D-000027	270E	02B4	0000	1111111111111111111111111111111111111111111111111111111111111111111111
25	D-000010	2DA2	04E8	0000	1111111111111111111111111111111111111111111111111111111111111111111111
26	D-000029	2728	22B6	0000	1111111111111111111111111111111111111111111111111111111111111111111111
27	D-00001A	2290	245D	0000	1111111111111111111111111111111111111111111111111111111111111111123456
28	D-000007	2D2C	2997	0000	1111111111111111111111111111111111111111111111111111111111111111111111
29	D-000017	2A6B	2B82	0000	1-1111111-111111111-1-111-1111111-111111111111111111111111111111123456
30	D-000024	2E6B	3A56	0000	1111111111111111111111111111111111111111111111111111111111111111111111
31	A---1200	035A	0C76	00AA	1111111111111111111111111111111111111111111111111111111111111111111111
32	D-00000D	2E2C	296D	0000	1111111111111111111111111111111111111111111111111111111111111111111111
33	D-000026	03FE	2286	0000	66--
34	A---1500	01E8	0BEF	0014	1111111111111111111111111111111111234566------------------------------
35	D-000004	2DFC	044B	0000	1111111111111111111111111111111111111111111111111111111111111111111111
36	D-000002	2DFA	0001	0000	--11111111111111111111111111111111111111111111111111111111111111111111
37	D-000026	03DC	2349	0000	-------------111111121111234566---------------------------------------
38	D-000012	2E6E	1760	0000	----------------111111111111111111111111111111111111111111111111111111
39	D-000026	03F4	2289	0000	---111111121111234566---------
40	A---2202	3490	3A77	00FA	--1-1111111111111111
41	A---6154	34E4	2B95	0138	---11-1111-11111-111
42	A---3113	34C6	38AE	0100	---1-11111111111
43	A---1277	0BA8	30BB	001E	--1-11

"-" = NO SURVEILLANCE FILE INFORMATION COLLECTED
"1" = TRACK UPDATED NORMALLY BY A TARGET REPORT
"2" = TRACK COASTED FOR THE FIRST TIME
"3" = TRACK COASTED FOR THE SECOND SCAN IN A ROW
"4" = TRACK COASTED FOR THE THIRD SCAN IN A ROW
"5" = TRACK COASTED FOR THE FOURTH SCAN IN A ROW
"6" = TRACK COASTED FOR THE FIFTH SCAN IN A ROW
"6" = TRACK DROPPED (WHEN PRECEDED BY ANOTHER "6")

TABLE 3. TRACK PERFORMANCE FOR FAILURE TEST 1

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 61 71 81 91 101 111
1	A---1200	10B4	0049	0080	11111111123111111111111111111111111111111111234566--------------------
2	D-000027	26DA	0285	0000	111111111-21111111111111111111111111111111111234566-------------------
3	D-000010	2DE2	04EC	0000	11111111-121111111111111111111111111111111111234566-------------------
4	A---4215	33C2	0785	0096	11111111123111111111111111111111111111111111234566--------------------
5	A---1700	086A	085E	0069	111111111231234566--
6	A---6754	26E4	1286	0096	11111111123111111111111111111111111111111111234566--------------------
7	A---1743	1ED6	1607	00C8	--
8	A---1600	1BAE	1D42	0096	11111111231111111111111111234566--------------------------------------
9	A---1700	2362	1DE1	0000	111111112311111111111111111234566-------------------------------------
10	A---4026	23D2	2177	0086	111111112311111111111111-111111-11-111-11-11234566--------------------
11	A---2200	26F2	222E	008C	111111112311111111111111-111111-11-111-11-11234566--------------------
12	D-000029	26F4	2284	0000	11111111-211111111111111111111111111111111111234566--------------------
13	D-00001A	2282	2473	0000	11111111-211111111111111111111111111111111111234566--------------------
14	A---5474	2328	2461	0064	11111111231111111111111111111111111111111111234566--------------------
15	A---5271	2232	2485	0050	11111111231111111111111111111111111111111111234566--------------------
16	D-000007	2D5E	2999	0000	11111111-211111111111111111111111111111111111234566--------------------
17	A---1200	3268	2965	0078	11111111231111111111111111111111111111111111234566--------------------
18	A---1200	31BC	2993	0078	11111111231111111111111111111111111111111111234566--------------------
19	D-000017	2A86	2B9F	0000	1-1-1111-21-111111-111-1-1-111111111111111111234566-------------------
20	A---2525	2954	2C4A	0040	111111111231111111111111111111111111111111111234566-------------------
21	A---1700	0402	319B	0064	111111111231234566--
22	A---7465	26FC	3285	0096	111111111231111111111111111111111111111111111234566-------------------
23	A---1700	0972	3373	0000	111111111234566---
24	A---1743	1E88	3477	00C8	--
25	A---1100	13DC	3516	012C	1111111112311111111111111111111111111111111111111111111111111---------
26	D-000025	2D70	39ED	0000	111111111-21111111111111111111111111111111111234566-------------------
27	A---4111	0B52	3A5A	012C	111111111231121111111111111111111111111111111234566-------------------
28	A---1252	32B0	3C91	012C	111111111231111111111111111111111111111111111234566-------------------
29	A---1752	1362	3F45	0064	--
30	D-000024	2E66	3A56	0000	111111111-21111111111111111111111111111111111234566-------------------
31	A---1200	035E	0C76	00AA	11111111123111111111111111111111111111111111234566--------------------
32	D-00000D	2E2A	296D	0000	11111111-211111111111111111111111111111111111234566--------------------
33	D-000026	03E2	2335	0000	--
34	A---1500	01E6	0BF1	0014	111111111231111111111111111111111234566-------------------------------
35	D-000004	2DFA	044C	0000	111111111-231111111111111111111111111111111111234566-------------------
36	D-000002	2DFA	0002	0000	111111111-231111111111111111111111111111111111234566-------------------
37	D-000026	0410	21F9	0000	-----------11111121111234566--
38	D-000012	2E6C	1762	0000	------------11111111111111111111111111111111234566--------------------
39	D-000026	03F4	2284	0000	---111234566--------------------

EMS-1 FAILED

MEMORY FAILED

MODEM FAILED

ARIES STOPPED

SS001X---BEACON SCHEDULING
SS002X---TRANSACTION PREP/UPDATE
SS012X---BEACON FORMATTING
SS014X---DABS TRACK UPDATE

TABLE 4. TRACK PERFORMANCE FOR FAILURE TEST 2

```
SURVEILLANCE FILE FIRMNESS CHART
                                               51        61        71        81        91        101       111
SURV   DABS &                                  :         :         :         :         :         :         :
FILE   ATCRBS    START  START  START           :         :         :         :         :         :         :
NUMBER IDENTITY  RANGE  AZIMTH ALTITUDE        :         :         :         :         :         :         :

   1   A---1200  10B2   0049   0080     1111111112111111112312312345-6----------------------------------------
   2   D-000027  26DA   02B4   0000     1111111112111111111231111111-231111111-1111111111111111111111111111111
   3   D-000010  2DE2   04E7   0000     1111111112111111111231111111-23111111-1212341111111111111111111111111
   4   A---4815  33C2   07B5   0096     1111111112111111111231111111-2311111111-211111111111111111111111111111
   5   A---1700  0B6A   0B5D   0069     111111111211234566---------------------------------------------------
   6   A---6754  26E4   12B5   0096     11111111231111111112311111111-311111111-2111111111111111111111111111111
   7   A---1743  1ED8   1608   00C8     ----------------------------------------------------------------------
   8   A---1600  1BAE   1D42   0096     111111112311111111231111111112-451234566-----------------------------
   9   A---1700  2364   1DDD   0096     111111112311111111231111111112-4566----------------------------------
  10   A---4026  23D2   2177   0086     1111111121111111112341111111-3-1-111-1-1111-111-11-11-11-11111-1111111
  11   A---2200  26F2   222F   008C     11111111211111111112311111111-3-1-11-11-111-111111111-11-11-11-1111111
  12   D-000029  26F4   22B2   0000     11111111211111111112311111111-311111111-11111111111111111111111111111111
  13   D-00001A  22B2   2474   0000     11111111231111111112311111111-311111111-11111111111111111111111234566-
  14   A---5474  232A   2464   0064     11111111231111111112311111111-311111111-11111111111111111111111234566-
  15   A---5271  2230   2486   0050     11111111231111111112311111111-311111111-11111111111111111111111234566-
  16   D-000007  2D5E   2998   0000     11111111211111111112311111111-311111111-2111111111111111111111111111111
  17   A---1200  326C   2965   0078     11111111231111111112311111111-311111111-1111111111111111111111111111111
  18   A---1200  31BA   2994   0078     11111111231111111112311111111-311111111-1111111111111111112111111111111
  19   D-000017  2A86   2B9C   0000     11-1111211-1111113-1-1111123111111-11-111111111111111111111111234566-
  20   A---2525  2956   2C49   0040     111111111211111111123111111111231111111111-1111111111111111111111112341234
  21   A---1700  0400   319A   0064     111111111211234123-4566-----------------------------------------------
  22   A---7465  26FE   32B5   0096     1111111112111111111231111111112311111111-111111111111111111111111111111
  23   A---1700  0970   3372   0000     111111111211234566---------------------------------------------------
  24   A---1743  1E88   3476   00C8     ----------------------------------------------------------------------
  25   A---1100  13DC   3515   012C     11111111121111111111111111111111111111111111111111111111111111111111111
  26   D-000025  2D70   39ED   0000     1111111112111111111231111111112311111111-111111111111111111111111111111
  27   A---4111  0B52   3A5B   012C     11111111121111111112311111111123111111111-111111111111111111-11-111111-
  28   A---1252  32AE   3C8E   012C     1111111112111111111231111111-23111111-21111111111111111111111111111111
  29   A---1752  1362   3F43   0064     ----------------------------------------------------------------------
  30   D-000024  2E66   3A56   0000     11111111121111111112311111111123111111111-11111111111111111111111111111
  31   A---1200  035C   0C76   00AA     111111112311111111234111111-23111111-2311111111111111111111111111111111
  32   D-00000D  2E2A   296D   0000     111111112121111111231111111-31111111-211111111111111111111111111111111
  33   D-000026  03E2   2332   0000     ----------------------------------------------------------------------
  34   A---1500  01E8   0BF1   0014     1111111-11111111112311111111-231234123-4566---------------------------
  35   A---1700  033E   0227   0000     4566------------------------------------------------------------------
  36   D-000004  2DFA   044B   0000     11111111121111111112311111111-231111111-2111111111111111111111111111111
  37   D-000002  2DF8   0001   0000     1111111112111111111231111111123111111111-23111111111111111111111111111111
  38   D-000026  03DC   2346   0000     -----------11111123121 12345-6----------------------------------------
  39   D-000012  2E6C   1760   0000     --------------111123111111111-311111111-11111111111111111111111111111111
  40   A---1200  0E3E   0D22   00B0     ----------------------111111-121111111-2311111111111111111111111111111
  41   D-000026  040C   21FF   0000     ------------------------------------------111111211111234566---------
  42   A---2222  348E   3A78   00FA     --------------------------------------------------1-1111111111111111111
  43   A---6154  34E2   2B96   0138     ---------------------------------------------------11-11-11111-1111-1-
  44   A---3113  34C4   38AD   0100     -------------------------------------------------------1-111111111111
  45   A---1100  058E   16AB   012C     --------------------------------------------------------111111111111
  46   A---1277  0BAA   308A   001E     -----------------------------------------------------------------1-1111
                                                :          :         :          :          :         :
                                                :          :         :          :          :         :
                                            COMPUTER   COMPUTER   COMPUTER   COMPUTER    MEMORY    MODEM
                                             FAILED     FAILED     FAILED     FAILED     FAILED    FAILED
                                                :          :          :          :
                                                :          :          :     SS014X---DABS TRACK UPDATE
                                                :          :      SS012X-------------BEACON FORMATTING
                                                :      SS002X------------------------TRANSACTION PREP/UPDATE
                                            SS001X-----------------------------------BEACON SCHEDULING
```

TABLE 5. TRACK PERFORMANCE FOR FAILURE TEST 3

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 61 71 81 91 101 111
1	A---1200	10B4	0049	0080	1111111112311111111-111111111-231111111-1231234566---------------------
2	D-000087	26DA	02B2	0000	111111111211111111-1111111111211111111-21111111111111111111111111111111
3	D-000010	2BE0	04EB	0000	111111111211111111-1111111111211111111-21111111111111111111111111111111
4	A---4215	33C2	07B5	0096	111111111231111111-111111111-231111111-21111111111111111111111111111111
5	A---1700	0B6A	0B5E	0069	11111111121212112345 66--
6	A---6754	26E4	12B5	0096	11111111-111111111-211111111-211111111-11111111111111111111111111111111
7	A---1743	1ED8	1607	00C8	--
8	A---1600	1BAC	1D42	0096	11111111-111111111-211111111-34566------------------------------------
9	A---1700	2364	1DDD	0096	11111111-121111111-211111111-345123456-6------------------------------
10	A---4026	23D2	2176	0086	11111111-111111111-2111-11-1-211111-11-1-111-1-111-111-111-111111-1111
11	A---2200	26F2	2230	008C	11111111-111111111-2111-11-1-211111-11-1-111-1-111-111-1-1-111111-1111
12	D-000029	26F4	22B2	0000	11111111-111111111-211111111-111111111-11111111111111111111111111111111
13	D-00001A	22B2	2472	0000	11111111-111111111-211111111-111111111-11111111111111111111111111212345
14	A---5474	232A	2461	0064	11111111-111111111-211111111-311111111-11111111111111111111111111234566
15	A---5271	2232	2486	0050	11111111-111111111-211111111-311111111-11111111111111111111111111231123
16	D-000007	2D5C	2997	0000	11111111-111111111-211111111-111111111-11111111111111111111111111111111
17	A---1200	326C	2964	0078	11111111-311111111-211111111-311111111-11111111111111111111111111111111
18	A---1200	31BC	2995	0078	11111111-121112111-211211234-66---------------------------------------
19	D-000017	2A88	28A0	0000	1-111-1-111-11-1111211-11-1112111111111-111111111111111111111111234566
20	A---2525	2956	2C4A	0040	1111111121-1111111211111111231111111111-111111111111111111111111234123
21	A---1700	0400	319B	0064	111111111211212345--6---
22	A---7465	26FE	32B6	0096	1111111112111111111211111111112111111111-111111111111111111111111111111
23	A---1700	0970	3373	0000	11111111121112345 6-6---
24	A---1743	1E88	3476	00C8	6---
25	A---1100	130C	3516	012C	1111111112311111111111111111111111111111111111111111111111111111-----
26	D-000025	2D70	39EE	0000	111111111211111111121111111111211111111112111111111111111111111111111
27	A---4111	0B52	3A5E	0000	11111111123111111112111111111123111111111-1111111111111111111111111-1111
28	A---1252	32AE	3C92	012C	111111111231111111-1111111111231111111-211111111111111111111111111111111
29	A---1752	1360	3F45	0064	--
30	D-000024	2E66	3A56	0000	111111111211111111121111111111211111111112111111111111111111111111111111
31	A---1200	035C	0C75	00AA	11111111-211111111-111111111-231111111-21111111111111111111111111111111
32	D-00000D	2E2A	2969	0000	11111111-111111111-211111111-111111111-11111111111111111111111111111111
33	D-000026	03E2	232F	0000	6---
34	A---1300	01E6	0BF0	0014	11111111-121111111-111111111-231123123-4566---------------------------
35	D-000004	2DFA	044C	0000	111111111211111111-1111111111211111111-21111111111111111111111111111111
36	D-000002	2DF8	0001	0000	1-1111111211111111-2111111111211111111-21111111111111111111111111111111
37	A---1200	2768	2774	0078	-----------1111111-211111111-311111111-1111111111111111111111111112111
38	A---1700	0938	392F	0069	-----------1-1234566--
39	A---1700	0648	0905	0064	------------123456--6---
40	D-000026	03DA	2348	0000	------------111111-211111234-66---------------------------------------
41	D-000012	2E6C	1763	0000	---------------111-211111111-211111111-1111111111111111111111111111111
42	A---1200	11B4	1003	0080	---1111111111111111111111111111
43	D-000026	03F4	22AF	0000	---11111121111234566---------
44	A---2222	348C	3A76	00FA	---1-11111111111111111
45	A---6154	34DE	2B97	0138	--11-111-11-1-11-111
46	A---3113	33C2	38B4	0100	--1-111111111
47	A---1100	0590	16AC	012C	---1111111111
48	A---1277	0BAC	30BB	001E	---1-111

COMPUTER FAILED | COMPUTER FAILED | COMPUTER FAILED | COMPUTER FAILED | MEMORY FAILED | MODEM FAILED

SS00FX---IPC/PERF. MONITOR

SS008X--------------ATCRBS TARGET TO TRACK

SS003X-------------------------DPMS

SA01DX-----------------------------------ATCRBS R/R CORRELATION

All four computer failures caused data extraction to miss collecting all of the surveillance file entries. The first computer failure caused 6 tracks to coast for two scans, 25 tracks coasted for one scan, 1 track remained solid. The second computer failure caused 31 tracks to coast for one scan, 1 track remained solid. The third computer failure caused 11 tracks to coast for two scans, 16 tracks were coasted for one scan, 1 track remained solid. The fourth computer failure caused all but 1 track to coast for one scan, 1 track remained solid. The memory and modem failures proved to be successful.

A problem with failure recovery was encountered as shown in table 6 for test 4. Following the first (SS00AX) and second (SA01EX) computer failures, two spare computers remained available to handle up to two more computer failures. These two spares were SS019X (primary standby) and SC023X (comm spare). When the third computer failure occurred, its task should have been assigned to the primary standby computer and the Comm spare should have taken over as a new primary standby, thus being available as a spare for the fourth failure. In actuality, when the third computer failure occurred, the primary standby computer also failed. The Comm spare took over the task of the failed third computer leaving no more spares to accommodate the fourth computer failure.

The cause of this problem is still being traced. It initially appeared to be a hardware problem with the computer acting as the primary standby following the second failure. Further testing has found no hardware problems. The failure/recovery software itself is now under investigation.

The results of test 5 presented in table 7 indicate that the DABS sensor kept the original track file numbers for all targets throughout the sequence of failures. No tracks were coasted as a result of any of the failures. Overall, the sensor behaved as if no failures were invoked at all.

The DABS sensor kept the original track file numbers on all targets throughout the sequence of failures for test 6 as shown in table 8. The first computer failure caused 4 tracks to coast for one scan. The second computer failure caused 6 tracks to coast for one scan. The third computer failure caused 3 tracks to coast for one scan. The fourth computer failure caused 11 tracks to coast for one scan and 3 other tracks to coast for two scans. The memory and modem failures caused no problems.

Once again, the sensor did not initiate any unnecessary new tracks, as indicated in table 9, for which test 7 results are presented. The ensemble failure caused most tracks to coast for two scans. Memory and modem failures posed no problems.

Table 10 indicates that the DABS sensor kept the original track file numbers for all but three ATCRBS targets throughout the sequence of failures for the last of the eight failure conditions. The ensemble failure caused tracks 5, 13, and 14 to be reinitiated as tracks 42, 43, and 44, respectively. The remaining 29 tracks all coasted for four scans following the ensemble failure. Four scans of sensor inactivity is large and requires further investigation.

TABLE 6. TRACK PERFORMANCE FOR FAILURE TEST 4

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 : 61 : 71 : 81 : 91 : 101 : 111
1	A---1200	10B4	0047	0080	11111111112111111111111111111211111111-------------------------------
2	D-000027	26DA	02B2	0000	11111111111111111111111111111111111111-------------------------------
3	D-000010	2DE2	04EB	0000	11111111111111111111111111111111111111-------------------------------
4	A---4215	33C2	0786	0096	11111111111111111111111111111111111111-------------------------------
5	A---1700	086A	0B5D	0069	11111111111121234566---
6	A---6754	26E4	12B5	0096	11111111111111111111111111112111111111-------------------------------
7	A---1743	1ED8	1608	00C8	---
8	A---1600	1BAC	1D41	0096	111111121111111111111111111234566------------------------------------
9	A---1700	2364	1DDF	0096	111111121111112111111111111234566------------------------------------
10	A---4026	23D2	2177	0086	1111111111111111111111-111111111111-11-------------------------------
11	A---2200	26F2	222E	008C	1111111111111111111111-1111111-111-11--------------------------------
12	D-000029	26F6	2285	0000	11111112111111111111111111111111111111-------------------------------
13	D-00001A	22B2	2473	0000	11111112111111111111111111111111111111-------------------------------
14	A---5474	2328	2463	0064	11111112111111111111111111111111111111-------------------------------
15	A---5271	2232	2484	.0050	11111112111111111111111111111111111111-------------------------------
16	D-000007	2D5C	2997	0000	11111111111111111111111111111111111111-------------------------------
17	A---1200	326C	2964	0078	11111111111111111111111111111111111111-------------------------------
18	A---1200	31BC	2994	0078	11111111111111111111111111111111111111-------------------------------
19	D-000017	2A86	2B9F	0000	1-1111-11-1-1-1-1-11-1111111111111-1111------------------------------
20	A---2525	2956	2C4A	0040	111111111111111111111111111111111111111------------------------------
21	A---1700	0402	319A	0064	111111111111234566---
22	A---7465	26FC	32B6	0096	111111111111111111111111111111111111111------------------------------
23	A---1700	0970	3374	0000	111111111111234566---
24	A---1743	1EB8	3475	00C8	---
25	A---1100	13DC	3516	012C	111111111111111111111111111111111111111------------------------------
26	D-000025	2D70	39EC	0000	11111111111111111111111111111111111111-------------------------------
27	A---4111	0B52	3A5A	012C	111111111111111111111111121111111111111------------------------------
28	A---1252	32AE	3C91	012C	11111111111111111111111111111111111111-------------------------------
29	A---1752	1360	3F43	0064	---
30	D-000024	2E66	3A57	0000	11111111111111111111111111111111111111-------------------------------
31	A---1200	035A	0C75	00AA	11111111111111111111111111111111111111-------------------------------
32	D-00000D	2E2A	296C	0000	11111111111111111111111111111111111111-------------------------------
33	D-000026	03E0	2332	0000	---
34	A---1500	01E8	0BF0	0014	1111111-111111111111111111111111211234-------------------------------
35	D-000004	2DFA	0448	0000	11111111111111111111111111111111111111-------------------------------
36	D-000002	2DF8	0002	0000	11111111111111111111111111111111111111-------------------------------
37	D-000026	03DC	2343	0000	-----------111111112111123456--
38	D-000012	2E6C	1760	0000	-------------1111211111111121111111111-------------------------------

COMPUTER FAILED — COMPUTER FAILED — COMPUTER FAILED — COMPUTER FAILED

SS00DX---IPC SECTOR PROCESSING

SS00CX--------------IPC MASTER RESOLUTION

SA01EX-------------------------PERFORMANCE MONITOR

SS00AX-----------------------------------FAILURE RECOVERY

TABLE 7. TRACK PERFORMANCE FOR FAILURE TEST 5

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 61 71 81 91 101 111
1	A---1200	10B6	0049	0000	111111111111111111111111111111111111111111111111234566----------------
2	D-000027	26D8	02B2	0000	111111111111111111111111111111111111111111111111234566----------------
3	D-000010	2BE2	04E9	0000	111111111111111111111111111111111111111111111111234566----------------
4	A---4215	33C2	07B4	0096	111111111111111111111111111111111111111111111111234566----------------
5	A---1700	0B6C	0B5E	0069	11111111111111234566--
6	A---6754	26E2	12B5	0096	111111111111111111111111111111111111111111111111234566----------------
7	A---1743	1ED6	1609	00C8	--
8	A---1600	1BAE	1D42	0096	1111111111111111111111111111234566------------------------------------
9	A---1700	2366	1DDE	0096	1111111111111111111111111111234566------------------------------------
10	A---4026	23D2	2177	0086	111111111111111111111111-111111111111-1111111-113456-6----------------
11	A---2200	26F2	222F	008C	111111111111121111111111-111111111111-1111111-113456-6----------------
12	D-000029	26F4	22B6	0000	11111111111111111111111111111111111111111111111234566-----------------
13	D-00001A	2BB2	2475	0000	11111111111111111111111111111111111111111111111234566-----------------
14	A---3474	23BA	2462	0064	11111111111111111111111111111111111111111111111234566-----------------
15	A---5271	2B3B	2486	0050	11111111111111111111111111111111111111111111111234566-----------------
16	D-000007	2D5E	2997	0000	11111111111111111111111111111111111111111111111234566-----------------
17	A---1200	326C	2965	0078	11111111111111111111111111111111111111111111111234566-----------------
18	A---1200	31BC	2995	0078	11111111111111111111111111111111111111111111111234566-----------------
19	D-000017	2A88	28A1	0000	1111-1-1111111-1111-11-1-111111111111-1111111111234566----------------
20	A---2525	2956	2C48	0040	111111111111111111111111111111111111111111111111234566----------------
21	A---1700	0404	319A	0064	1111111111111234566---
22	A---7465	26FC	32B7	0096	111111111111111111111111111111111111111111111111234566----------------
23	A---1700	0972	3373	0000	1111111111111234566---
24	A---1743	1E88	3479	00C8	6---
25	A---1100	13DC	3517	012C	1111111111111111111111111111111111111111111111111111111111111111111111
26	D-000025	2D70	39ED	0000	111111111111111111111111111111111111111111111111234566----------------
27	A---4111	0B52	3A5A	012C	111111111111111111111111111111111111111111111111234566----------------
28	A---1252	32B2	3C90	012C	111111111111111111111111111111111111111111111111234566----------------
29	A---1752	1362	3F44	0064	--
30	D-000024	2E66	3A57	0000	111111111111111111111111111111111111111111111111234566----------------
31	A---1200	0356	0C76	00AA	111111111111111111111111111111111111111111111111234566----------------
32	D-00000D	2E2C	296F	0000	11111111111111111111111111111111111111111111111234566-----------------
33	D-000026	03E0	2337	0000	6---
34	A---1500	01E8	0BF2	0014	111111111111111111111111111111111234566-------------------------------
35	A---1700	02FC	3F23	0000	--
36	D-000004	2E00	044E	0000	111111111111111111111111111111111111111111111111234566----------------
37	D-000002	2DFC	0001	0000	-11111111111111111111111111111111111111111111111234566----------------
38	D-000026	03F6	22A6	0000	--------------11111121111234566---------------------------------------
39	D-000012	2E6E	1760	0000	---------------111111111111111111111111111111111234566----------------
40	D-000026	03F0	22C6	0000	---1111234566-----------------

ENS-5 FAILED

MEMORY FAILED

MODEM FAILED

ARIES STOPPED

SS00AX---FAILURE RECOVERY
SS00CX---IPC MASTER RESOLUTION
SS00DX---IPC SECTOR PROCESSING
SA01EX---PERFORMANCE MONITOR

TABLE 8. TRACK PERFORMANCE FOR FAILURE TEST 6

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 : 61 : 71 : 81 : 91 : 101 : 111
1	A---1200	10B4	0045	00B0	11111111211111111121111111112111111111-3111111111111111111111111111111
2	D-000027	26D8	02B6	0000	1111111111111111111111111111111111111112111111111111111111111111111111
3	D-000010	2DE2	04EC	0000	1111111111111111111111111111111111111112111111111111111111111111111111
4	A---4215	33C2	0785	0096	1111111111111111111111111111111111111112111111111111111111111111111111
5	A---1700	0B6A	0B64	0069	1111111111111234566---
6	A---6754	26E4	12B5	0096	11111111211111111121111111112111111111-1111111111111111111111111111111
7	A---7777	1ED8	1607	00C8	--
8	A---1600	1BAE	1D41	0096	111111111111111111111111111231234566----------------------------------
9	A---1700	2366	1DDE	0096	111111111111111111111111111234566-------------------------------------
10	A---2200	26F4	222E	008C	111111111111111111111111-111-1111-111-11-111-111111-111111111111111111
11	D-000029	26F4	22B6	0000	11111111111111111111111111111111111111-1111111111111111111111111111111
12	D-00001A	22B2	2474	0000	11111111111111111111111111111111111111-111111111111111111111111234566-
13	A---5474	232A	2463	0064	11111111111111111111111111111111111111-111111111111111111111111234566-
14	A---5271	2232	2485	0050	11111111111111111111111111111111111111-111111111111111111111111234566-
15	D-000007	2D5E	2996	0000	11111111111111111111111111111111111111-1111111111111111111111111111111
16	A---1200	326C	2964	0078	11111111111111111111111111111111111112-4111111111111111111111111111111
17	A---1200	31BC	2996	0078	1111111111111111111111111111111111211111-31111211111112111111111111111
18	D-000017	2A88	2BA2	0000	1-11-1-11-1-11-11-111-1-111111-111111112111111111111111111111112311234
19	A---2525	2956	2C49	0040	1111111111111111111111111111111111111112111111111111111111111112121234
20	A---1700	0400	319B	0064	111111111111234566--
21	A---7465	26FC	32B5	0096	1111111111111111111111111111111111111112111111111111111111111111111111
22	A---1700	0972	3372	0000	111111112111234566--
23	A---5757	1E88	3479	00C8	--
24	A---1100	13DC	3515	012C	1111111111111111111111111111111111111111111111111111111111111111------
25	D-000025	2D70	39EB	0000	1111111111111111111111111111111111111112111111111111111111111111111111
26	A---4111	0B52	3A5B	012C	111111111111111111111111111111111111111-11111111111-1111111111-1111111
27	A---1252	32B0	3CBF	012C	1111111111111111111111111111111111111112111111111111111111111111111111
28	A---1752	1360	3F43	0064	--
29	A---4026	239C	2191	0086	111111111111111111111111-11111111-111-11-111-11-111-1111111111-1111111
30	D-000024	2E66	3A56	0000	1111111111111111111111111111111111111112111111111111111111111111111111
31	A---1200	0356	0C76	00AA	1111111121111111112111111111111111111111123111111111111111111111111111
32	D-00000D	2E2C	296D	0000	11111111111111111111111111111111111111-1111111111111111111111111111111
33	D-000026	03E0	2336	0000	--
34	A---1500	01EA	0BF3	0014	111111111111111111211111111111111121234-566---------------------------
35	D-000004	2DFE	044F	0000	1111111111111111111111111111111111111112111111111111111111111111111111
36	D-000002	2DFC	0001	0000	1111111111111111111111111111111111111112111111111111111111111111111111
37	D-000026	03F6	22A1	0000	------------11111121111234566---
38	D-000012	2E6C	1762	0000	--------------1111211111111121111111111-1111111111111111111111111111111
39	D-000026	03F2	228C	0000	--111111121111234566----------
40	A---2222	3490	3A79	00FA	--1-111111111111111111
41	A---6154	34E2	2B97	0138	---1-111-11111-1-1-111
42	A---3113	34C6	38AD	0100	---1-1111111111111
43	A---1100	058E	16AC	012C	--111111111111
44	A---1277	0BA4	30BA	001E	--1-1111

```
COMPUTER    COMPUTER    COMPUTER    COMPUTER    MEMORY    MODEM
FAILED      FAILED      FAILED      FAILED      FAILED    FAILED

                                    SC021X---SURV RECEIVE/TRANSMIT
                        SS01BX--------------SPARE COMPUTER
            SS019X------------------------PRIMARY STANDBY
SS00AX-----------------------------------FAILURE RECOVERY
```

TABLE 9. TRACK PERFORMANCE FOR FAILURE TEST 7

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 61 71 81 91 101 111
1	A---1200	10B2	0046	0080	111111111211111111111111111111111111111111111234566-------------------
2	D-000027	26DA	02B5	0000	111111111211111111111111111111111111111111111234566-------------------
3	D-000010	2DE0	04EB	0000	111111111211111111111111111111111111111111111234566-------------------
4	A---4215	33C2	07B4	0096	111111111211111111111111111111111111111111111234566-------------------
5	A---1700	0B6B	0B5E	0069	111111111231234566--
6	A---6754	26E4	12B7	0096	111111112311111111111111111111111111111111111234566-------------------
7	A---1743	1ED6	1608	00C8	--
8	A---1600	1BAE	1D42	0096	11111111231111111111111111234566--------------------------------------
9	A---1700	2366	1DDE	0096	11111111231111111111111111234566--------------------------------------
10	A---4026	23D2	2177	0086	1111111123111111111111111111111111111-11111123456-6-------------------
11	A---2200	26F0	2230	008C	1111111123111111111111111111111111111-1111-123456-6-------------------
12	D-000029	26F4	22B5	0000	111111112311111111111111111111111111111111111234566-------------------
13	D-00001A	22B2	2474	0000	111111112311111111111111111111111111111111111234566-------------------
14	A---5474	232A	2463	0064	111111112311111111111111111111111111111111111234566-------------------
15	A---5271	2232	2487	0050	111111112311111111111111111111111111111111111234566-------------------
16	D-000007	2D5C	2999	0000	11111111231111111111111111111111111111111111234566--------------------
17	A---1200	326C	2964	0078	111111112311111111111111111111111111111111111234566-------------------
18	A---1200	31BA	2994	0078	111111112311111111111111111111111111111111111234566-------------------
19	D-000017	2ABB	2B9E	0000	1-111-1-2-3111-111111111111-1111-111111111111234566-------------------
20	A---1700	03FE	319B	0064	11111111121234566---
21	A---7465	26FE	32B8	0096	111111111231111111111111111111111111111111111234566-------------------
22	A---1743	1EB8	3475	00C8	--
23	D-000025	2D6E	39EC	0000	111111111231111111111111111111111111111111111234566-------------------
24	A---1252	32B0	3C91	012C	111111111231111111111111111111111111111111111234566-------------------
25	A---1752	1362	3F45	0000	--
26	A---1100	139C	3515	012C	1111111112311111111111111111111111111-111112-346-6--------------------
27	A---4111	0B54	39F7	012C	111111111231111111111111111111111111111111111235-66-------------------
28	A---2525	2928	2C66	0040	111111111231111111111111111111111111111111111234566-------------------
29	A---1700	0872	33DD	0000	11111111231234566---
30	D-000024	2E66	3A5B	0000	111111111231111111111111111111111111111111111234566-------------------
31	A---1200	035A	0C76	00AA	111111112311111111111111111111111111111111111234566-------------------
32	D-00000D	2E2A	296D	0000	111111112311111111111111111111111111111111111234566-------------------
33	D-000026	03E2	232E	0000	--
34	A---1500	01E4	0BEF	0014	1111111112111111111111111111111234566---------------------------------
35	D-000004	2DF8	044C	0000	111111111211111111111111111111111111111111111234566-------------------
36	D-000002	2DF6	0000	0000	111111111231111111111111111111111111111111111234566-------------------
37	D-000026	03FA	2295	0000	-----------11111112111123456 6---
38	D-000012	2E6C	1763	0000	-------------11111111111111111111111111111111234566-------------------
39	D-000026	03F6	22AC	0000	---1111234566-------------------

ENS-4 FAILED

MEMORY FAILED

MODEM FAILED

ARIES STOPPED

SS003X---DPMS
SS008X---ATCRBS TARGET TO TRACK
SS00AX---FAILURE RECOVERY
SS00FX---IPC CTL ALERT, LEVEL 3/7

TABLE 10. TRACK PERFORMANCE FOR FAILURE TEST 8

SURVEILLANCE FILE FIRMNESS CHART

SURV FILE NUMBER	DABS & ATCRBS IDENTITY	START RANGE	START AZIMTH	START ALTITUDE	51 61 71 81 91 101 111
1	D-000087	26DA	02B3	0000	111111111234511111111111111111111111111111111111111234566-------------
2	D-000010	2DE2	04EF	0000	111111111234511111111111111111111111111111111111111234566-------------
3	A---4215	33C2	07B5	0096	111111111234511111111111111111111111111111111111111234566-------------
4	A---1700	0B6C	0B5E	0069	111111111234566---
5	A---6754	26E2	12B5	0096	11111111234566--
6	A---1743	1ED6	1607	00C8	--
7	A---1600	1BAE	1D41	0096	11111111123451111111111111121234566-----------------------------------
8	A---1700	2364	1DDF	0096	11111111123451111111111111121234566-----------------------------------
9	A---4026	83D2	2178	0086	1111111112345111111111-1111-1111-111111111-1-111112345-66-------------
10	A---2200	26F2	222E	008C	1111111112345111111211-1111-2111-111111111-1-1111111345-66-------------
11	D-000029	26F4	22B3	0000	11111111123451111111111111111111111111111111111111234566--------------
12	D-00001A	22B2	2474	0000	111111111234511111111111111111111111111111111111111234566-------------
13	A---5474	232A	2463	0064	11111111234566--
14	A---5271	2232	24B7	0050	11111111234566--
15	D-000007	2D5E	2999	0000	11111111123451111111111111111111111111111111111111234566--------------
16	A---1200	326C	2964	0078	11111111123451111111111111111111111111111111111111234566--------------
17	A---1200	31BA	2994	0078	11111111123451111111111111111111111121111111111111111234566--------------
18	D-000017	2A88	2BA0	0000	-11-11112345-1111-1-1-11111111-1-1111111111111111111111234566-------------
19	A---2525	2956	2C4A	0040	111111111234511111111111111111111111111111111111111234566-------------
20	A---1700	0402	319B	0064	111111111234566---
21	A---7465	26FE	3286	0096	111111111234511111111111111111111111111111111111111234566-------------
22	A---1700	0972	3373	0000	111111111234566---
23	A---1743	1E8A	3476	00C8	--
24	A---1100	13DE	3514	012C	1111111112345111111111111111111111111111111111111111111111111-------
25	D-000025	2D70	39EC	0000	111111111234511111111111111111111111111111111111111234566-------------
26	A---4111	0B52	3A5B	012C	11111111123451111111111111111111111111111111111111235-66-------------
27	A---1252	32B0	3C8F	012C	111111111234511112111111111111111111111111111111111234566-------------
28	A---1752	1362	3F43	0064	--
29	A---1200	1048	0093	00B0	111111111234511111111111111111111111111111111111111234566-------------
30	D-000024	2E66	3A58	0000	111111111234511111111111111111111111111111111111111234566-------------
31	A---1200	0358	0C77	00AA	111111111234511111111111111111111111111111111111111234566-------------
32	D-00000D	2E2A	296D	0000	11111111234511111111111111111111111111111111111111234566--------------
33	D-000026	03E0	2336	0000	--
34	A---1500	01E8	0BF2	0014	1111111112345111111111111111111121234566------------------------------
35	A---1700	0414	0001	0069	--
36	D-000004	2DFC	044B	0000	111111111234511111111111111111111111111111111111111234566-------------
37	A---1700	0362	03BD	0070	--
38	A---1500	015C	3E17	0014	566---
39	D-000002	2DFC	0001	0000	111111111234511111111111111111111111111111111111111234566-------------
40	D-000012	2E6C	1761	0000	--------------1111111111111111111111111111111111111234566-------------
41	D-000026	041E	2146	0000	--------------1111121111234566--
42	A---6754	2CE4	1286	0096	---------------111111111111111111111111111111111111234566-------------
43	A---5474	2006	1F76	0064	---------------111111111111111111111111111111111111234566-------------
44	A---5271	1EE6	1FCC	0050	---------------111111111111111111111111111111111111234566-------------
45	D-000026	03F2	22BD	0000	---11111121234566-------------

ENS-1 FAILED — MEMORY FAILED — MODEM FAILED — ARIES STOPPED

SS001X---BEACON SCHEDULING
SS00AX---FAILURE RECOVERY
SS019X---PRIMARY STANDBY SPARE
SS01BX---SPARE STANDBY

The DABS sensor failure/recovery testing is summarized in the following paragraphs. The modem and memory failures were handled by the sensor without any problems. Both recovery processes proceeded as previously described and analysis of data verified the integrity of processing subsequent to the recoveries. Three of the four tests involving ensemble failures provided exceptionally good results. None of these ensemble failures caused any targets to coast for more than two scans or to be reinitiated with new tracks. The fourth test, with an ensemble failure, coasted all tracks for four scans and reinitiated three ATCRBS targets with new tracks. This behavior is not suprising since all but one redundant computer (SS01AX) failed within the ensemble. The remaining redundant computer activates only when the other three ensembles fail. This implementation causes the sensor to take more time to recover when multiple high ranking spares are lost in an ensemble failure. It should be noted that the normal task configuration does not place three redundant computers in the same ensemble.

Three of the four tests with individual computer failures did not encounter any problems with the sensor. Altogether, the 12 computer failures within those three tests caused a combined total of only five ATCRBS targets to be reinitiated with new tracks. The sensor generally recovered from these failures within one or two scans. The longest recovery occurred for the transaction preparation/update computer which caused 2 of the active 31 tracks to coast for three scans.

The fourth test with individual computer failures caused the sensor to shut itself down after the fourth computer failure. The primary computer defaulted when it attempted to resolve the functions of the failed third computer. This left no remaining spare computers to accommodate the fourth computer failure. Hence, the sensor shut itself down when the fourth failure was invoked. This problem is presently being investigated.

In several low probability failure events, full resumption of the tracking function requires three or four scans. However, for the preponderance of expected failure modes, there is a minimal impact on tracking. The remaining recovery software problems are minor and correctable with software modification. The overall NAFEC testing demonstrated the effectiveness of using a distributed computer system for failure/recovery functions.

DABS/ARTS III COMPARISON TESTS.

DABS/ARTS III comparison tests were accomplished at NAFEC using real world targets of opportunity and controlled test aircraft. Target reporting performance of the NAFEC DABS sensor was compared to that of the ARTS III system located at the airport surveillance radar site (ASR-5). The system consisted of a Beacon Data Acquisition System (BDAS) and an IOP being fed beacon data from the ATCBI-5. The antenna at the site was approximately 80 feet above ground level as compared to an antenna height of approximately 20 feet above ground level at the DABS site. This antenna height difference accounted for some differences in test results and will be discussed. In addition, the two sites are not collocated, but are separated by 1.3 nmi.

This geographical difference was considered when comparing test results. The primary purpose of the test was to compare the DABS in the ATCRBS mode to the ARTS. However, some tests were made with DABS in the DABS mode. These results are also presented.

The method of testing was to simultaneously record data extraction tapes of real world targets of opportunity and controlled aircraft at both sites. These data extraction tapes were then reduced to rho-theta plots and various program listings, using utility programs developed at NAFEC. All plots consisted of beacon or DABS reports. In addition, some statistical comparisons were made by manual analysis of data from program report listings. Two NAFEC aircraft: an Aero Commander, N-50, and a Gulfstream, N-48, were used for the comparison flights. They were equipped with both a DABS and ATCRBS transponder; however, only one transponder was used at any given time. The unused transponder was always turned off thereby preventing interference by the other. Table 11 outlines the various test parameters.

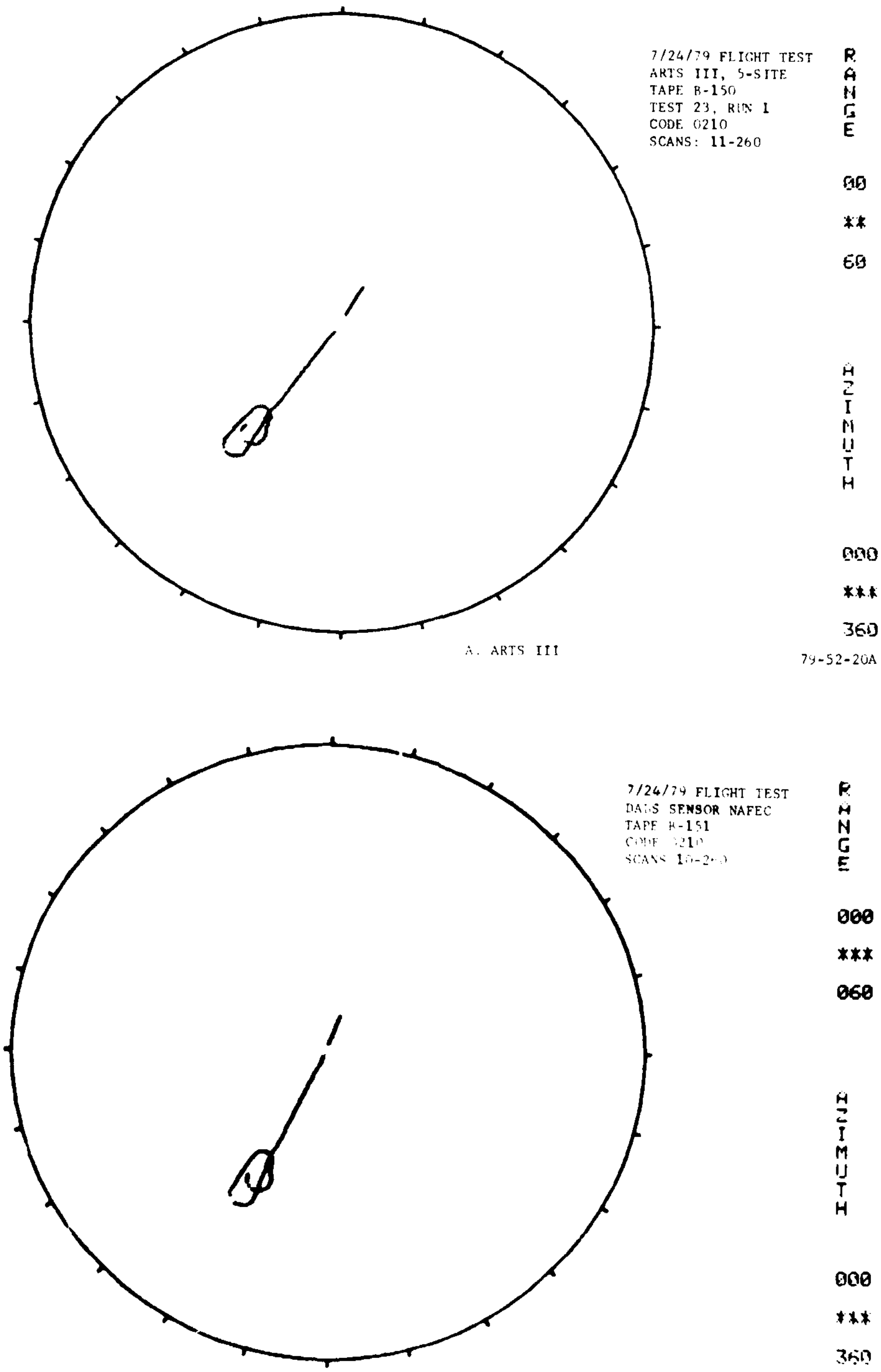
ARTS VERSUS DABS COMPARISON FOR CONTROLLED AIRCRAFT. Figures 20 through 32 are the rho-theta plots of controlled aircraft. For comparison purposes, the ARTS plots are on top and the DABS plots are on the bottom. This convention is used throughout. The plots are labeled as to date of flight, site, data extraction (DEX) tape number, range, azimuth, transponder code, scan numbers, and whether the DABS or ATCRBS mode of the DABS sensor was employed.

Figures 20 through 23 are comparison plots of a flight which executed a "race track" pattern at approximately a 30-nmi range, 125° azimuth, and a straight-in track over the sensors through the zenith cone. The approximate altitude and velocity are 4,300 feet and 240 knots, respectively. The aircraft used an ATCRBS transponder with mode A-code 0210. A review of the plots indicates that the DABS track is much smoother, has far less range and azimuth jitter, and is more solid than the ARTS track. Both sites have missing reports in the turns where the aircraft's antenna was shielded from the ground systems by the aircraft fuselage. It is apparent that the DABS had fewer misses. Antenna diversity was not employed during these tests and the single transponder antenna was located under the "belly" of the aircraft. The fact that no replies, instead of garbled replies, were received from the aircraft during the scans for which the test target was not detected, indicates that antenna shielding was the cause of the lost reports during turning maneuvers.

Of particular interest is the fact that a target of opportunity, mode A-code 0200, crossed 800 feet above the NAFEC test aircraft mode A-code 0210, at a point approximately 23 nmi, as indicated in figure 21. Plots of this crossing are depicted in figure 22, using unique symbols for the mode A-code for each aircraft. The NAFEC test aircraft, mode A-code 0210, is assigned the symbol "□" and the target of opportunity, mode A-code 0200, is assigned the symbol "X." Any other mode A-codes appear on the plots as a "•." Therefore, if one of the aircraft in question has a change in mode A-code information, the symbol appears as a dot.

TABLE 11. DABS/ARTS III COMPARISON FLIGHT TEST

Test	Run	Date	Data Extraction Tape No.	Type Airplane	Transponder	ATCRBS ID	DABS ID	Speed Knots	Altitude (Ft)
23	01	7/24/79	B-151 DABS B-150 ARTS	Gulfstream N-48	ATCRBS	0210	N/A	240	4,300-5,400
23	02	7/24/79	B-154 DABS B-153 ARTS	Gulfstream N-48	ATCRBS	0210	N/A	240	6,400
24	01	7/24/79	E-48 DABS B-156 ARTS	Gulfstream N-48	DABS	0252	7FFFFF	240	7,400
24	02	7/24/79	E-45 DABS E-44 ARTS	Gulfstream N-48	DABS	0252	7FFFFF	240	7,400
69	01	8/1/79	M-208 DABS M-210 ARTS	Gulfstream N-48	ATCRBS	0201	N/A	240	8,300
69	02	8/1/79	M-211 DABS M-213 ARTS	Gulfstream N-48	ATCRBS	0201	N/A	240	8,300
70	01	8/1/79	M-214 DABS M-216 ARTS	Gulfstream N-48	DABS	0202	7FFFFF	240	8,300
82	01	8/9/79	M-247 DABS M-251 ARTS	Commander N-50	ATCRBS	0203	N/A	140	200-1,700



A. ARTS III

79-52-20A

B. DABS SENSOR ([illegible])

79-52-20B

FIGURE 20. RACE TRACK PATTERN ARTS/DABS

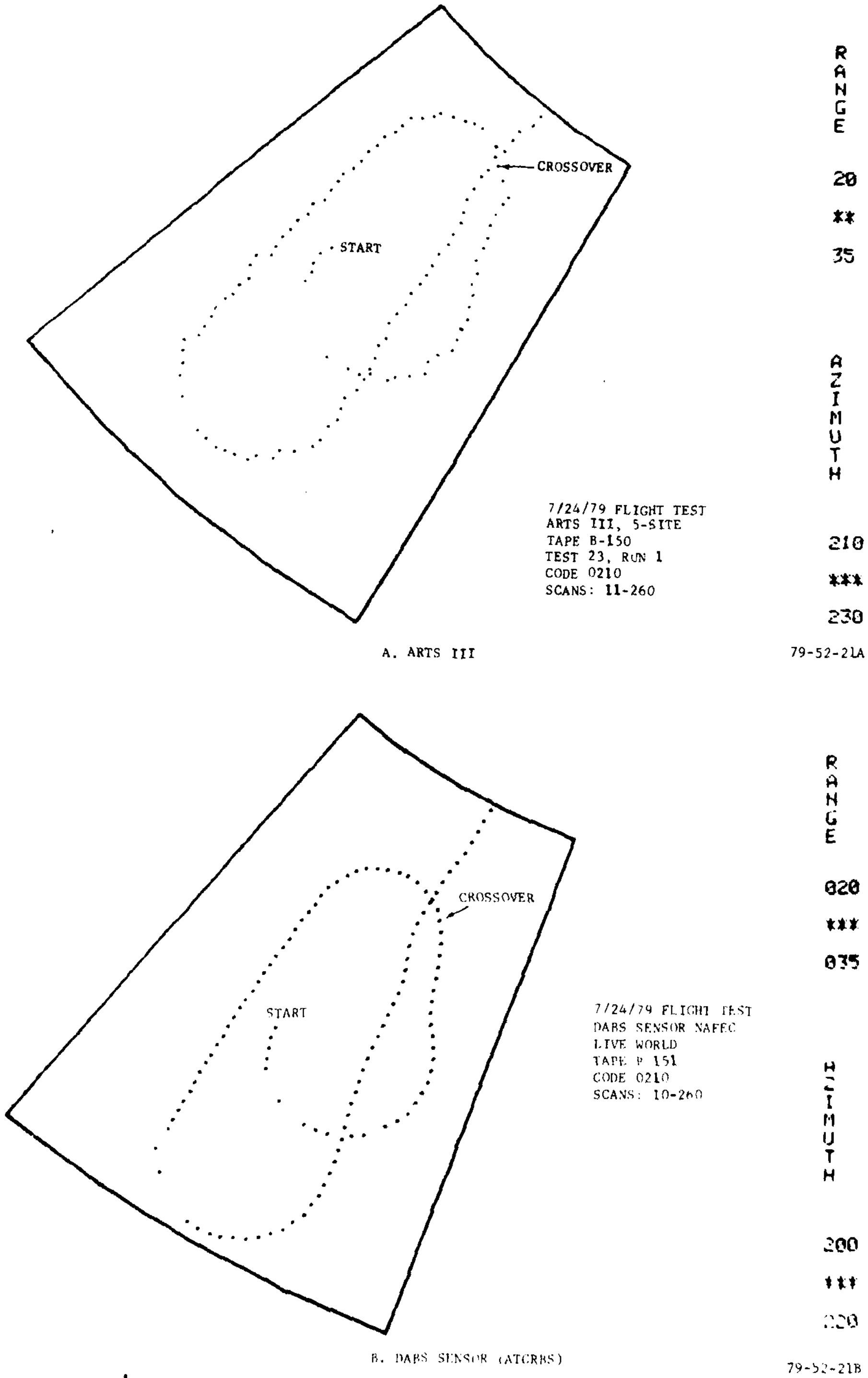
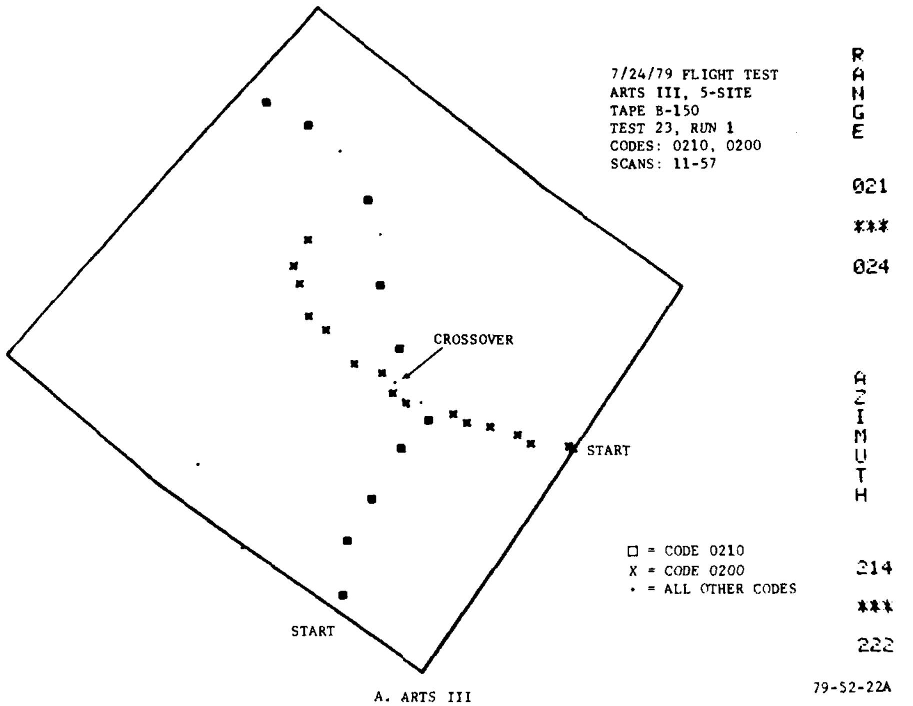
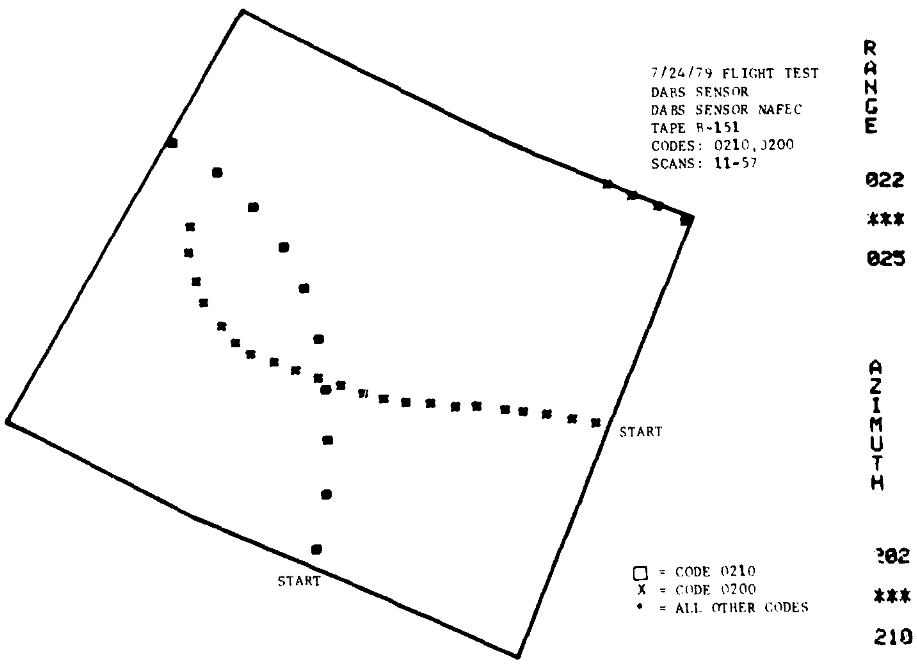


FIGURE 21. EXPANDED VIEW OF RACE TRACK PATTERN

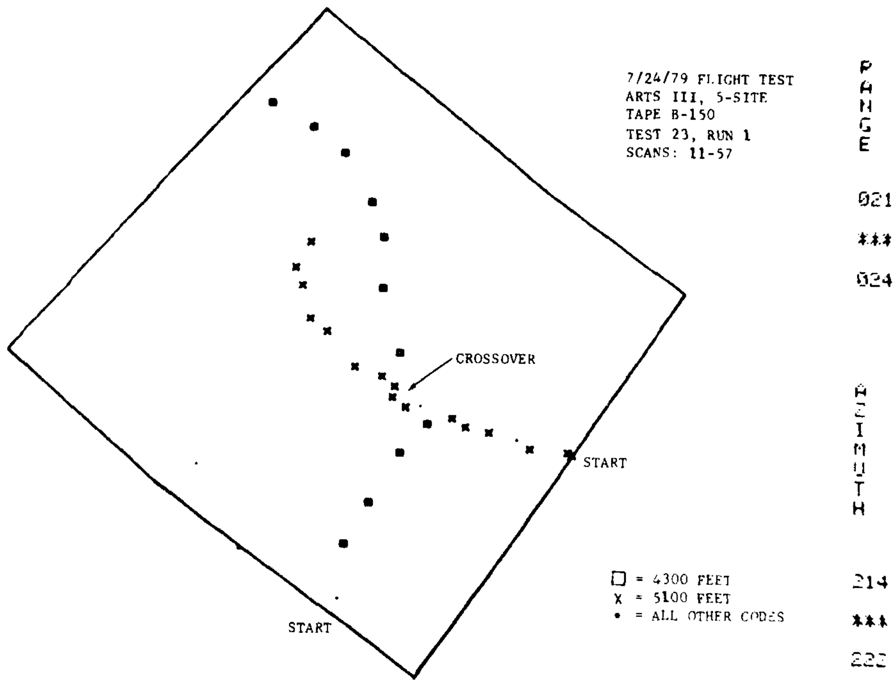


A. ARTS III



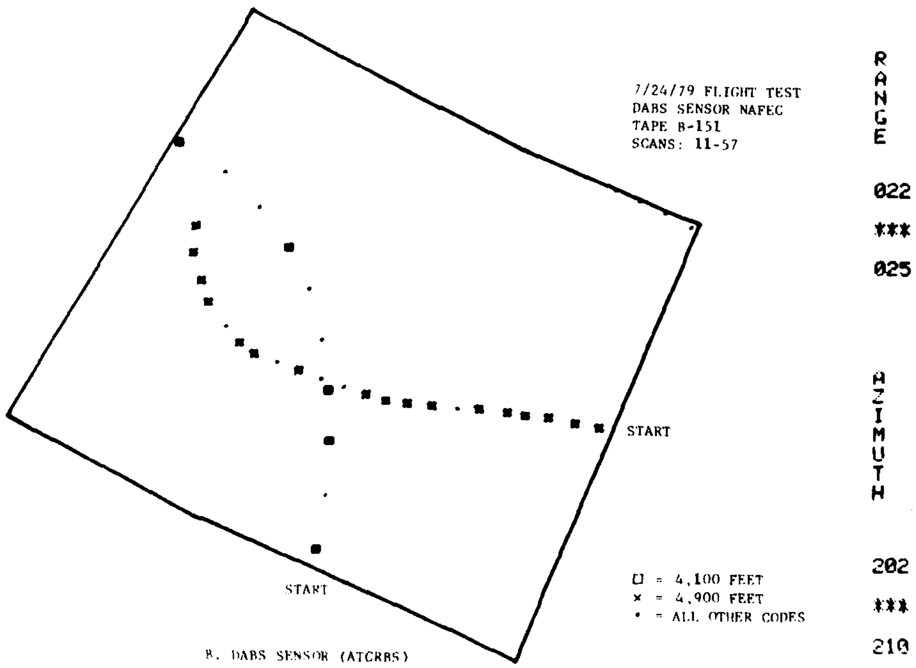
B. DABS SENSOR (ATCRBS)

FIGURE 22. CODE IDENTITY CROSSOVER PLOT



A. ARTS III

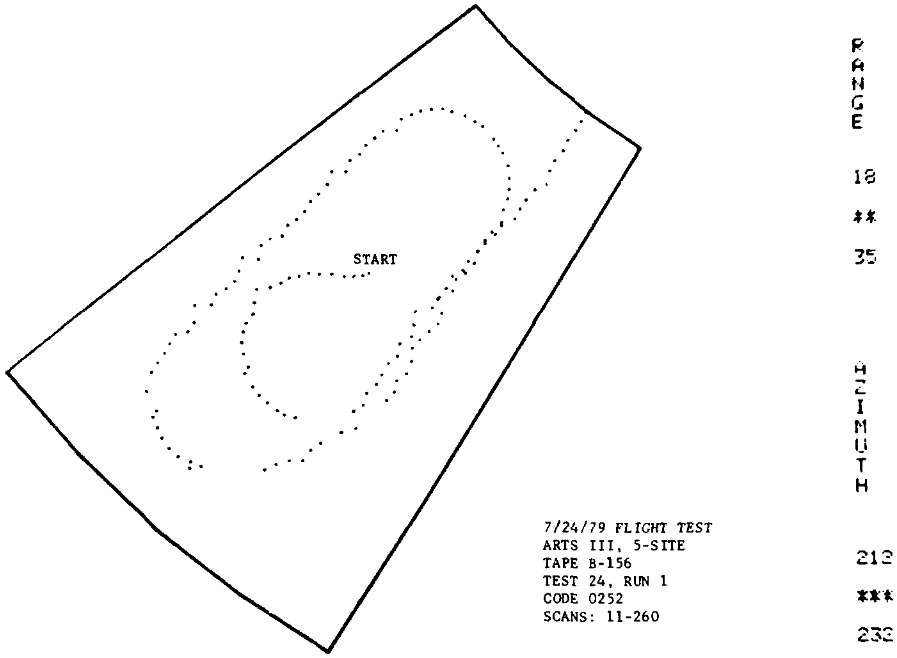
79-52-23A



B. DABS SENSOR (ATCRBS)

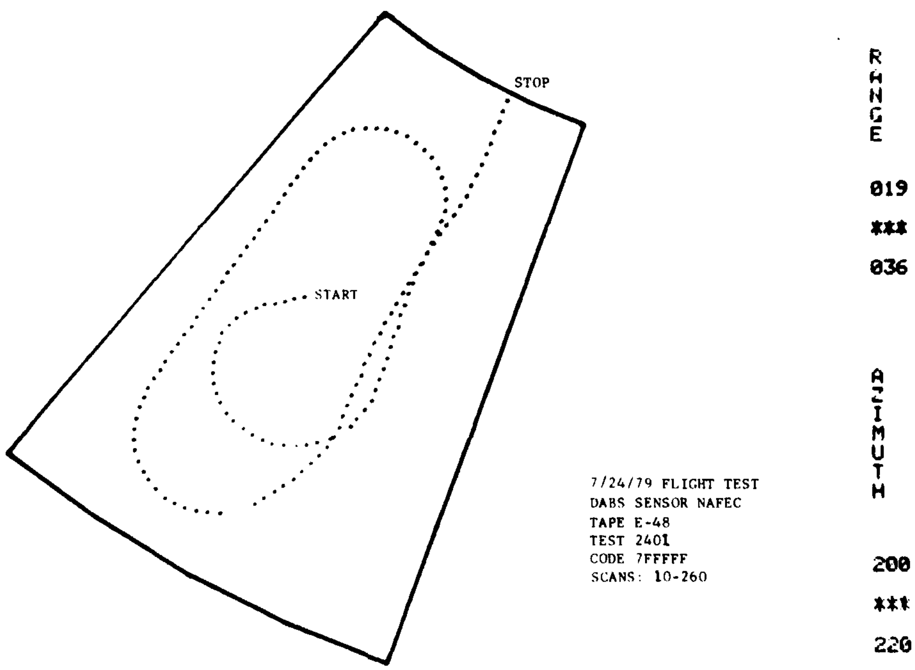
79-52-23B

FIGURE 23. ALTITUDE CROSSOVER PLOT



A. ARTS III

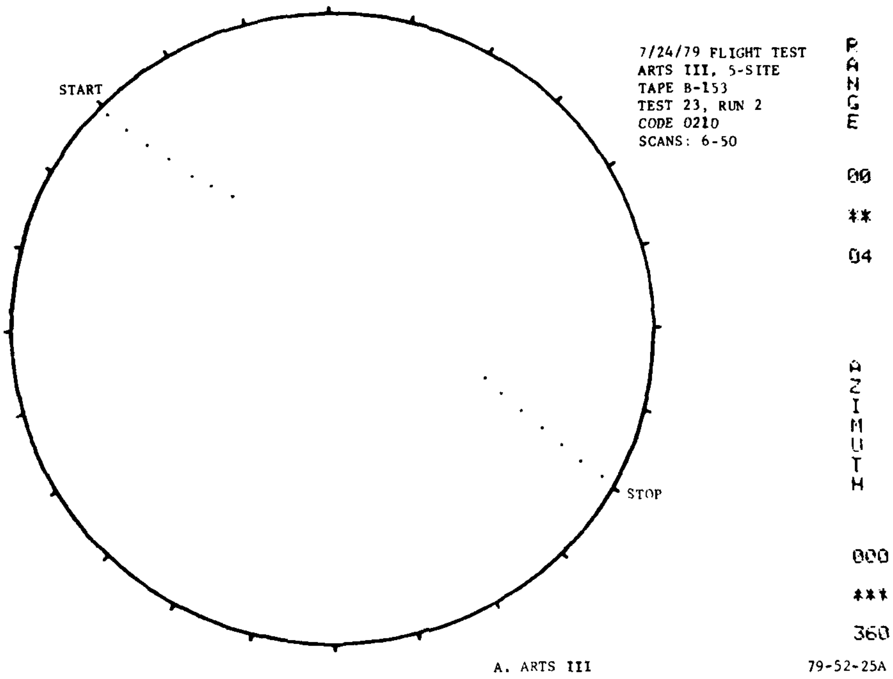
79-52-24A



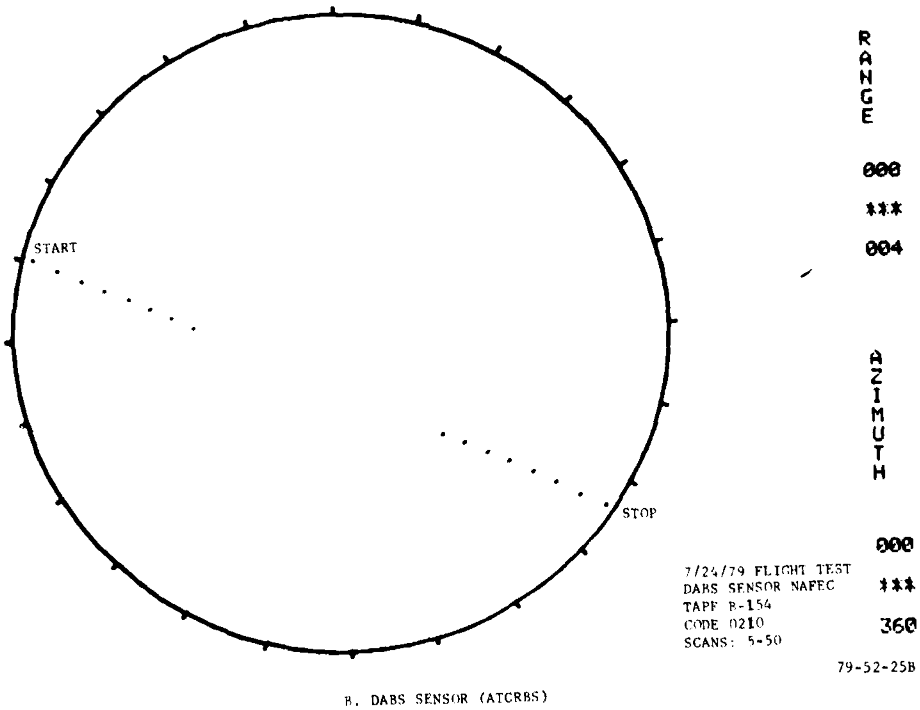
B. DABS SENSOR (DABS)

79-52-24B

FIGURE 24. EXPANDED VIEW OF RACE TRACK PATTERN

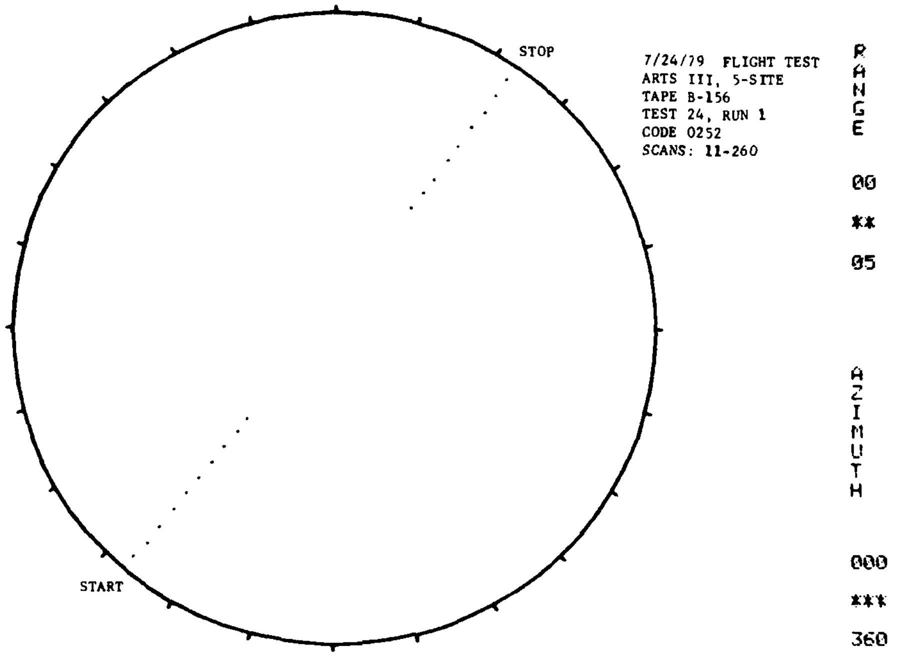


A. ARTS III



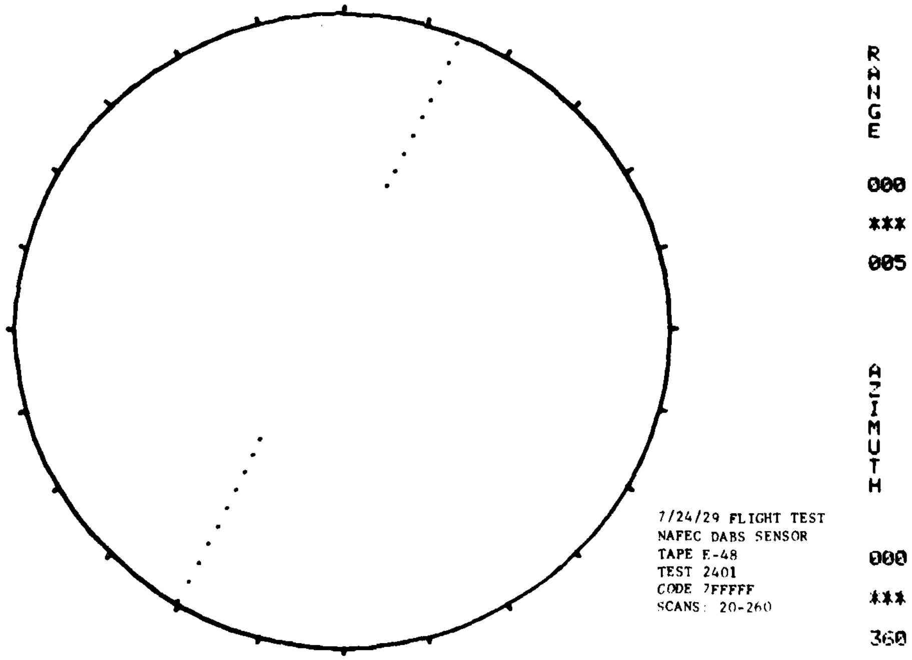
B. DABS SENSOR (ATCRBS)

FIGURE 25. ZENITH CONE CROSSINGS



A. ARTS III

79-52-26A



B. DABS SENSOR (DABS)

79-52-26B

FIGURE 26. ZENITH CONE CROSSINGS

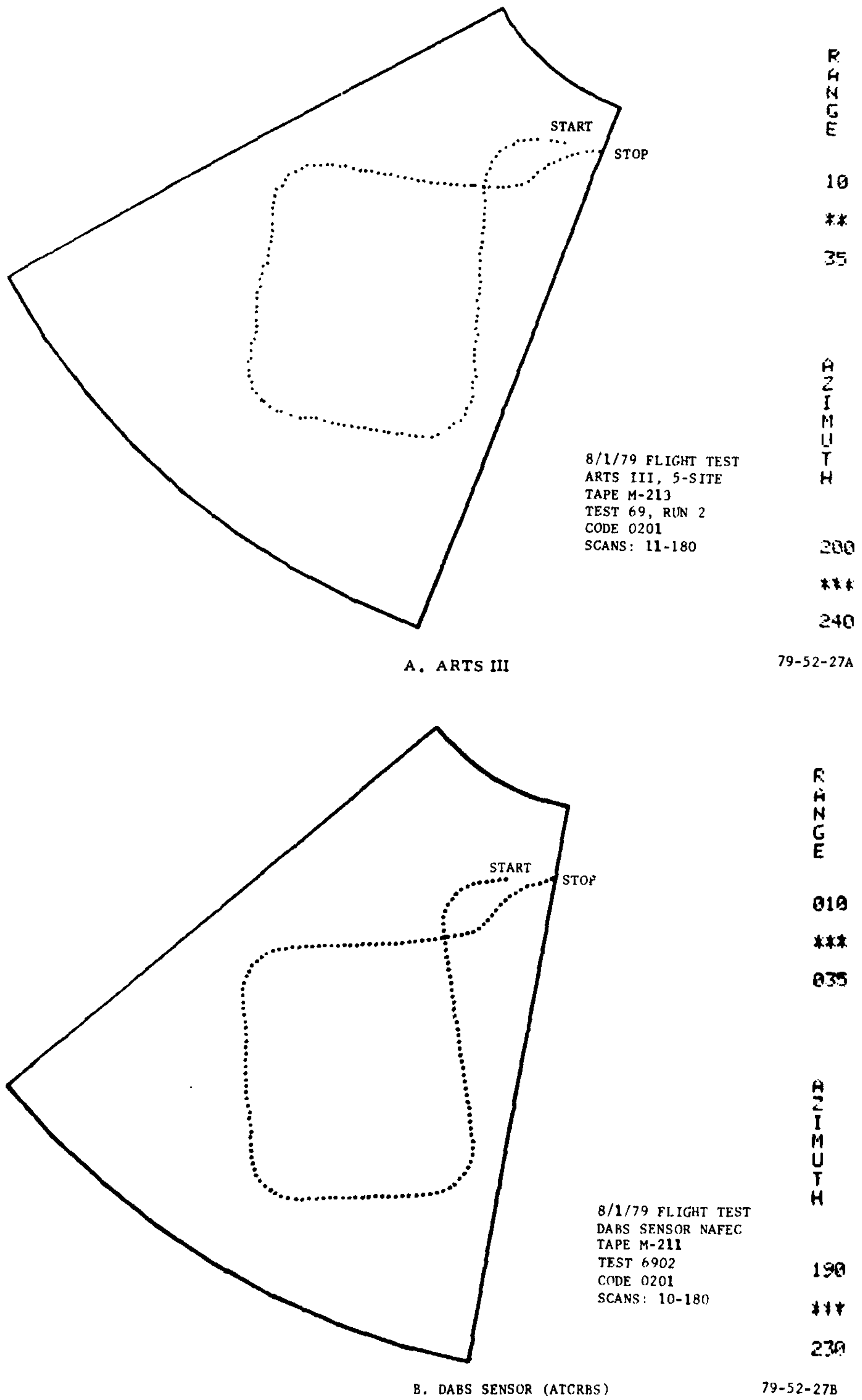
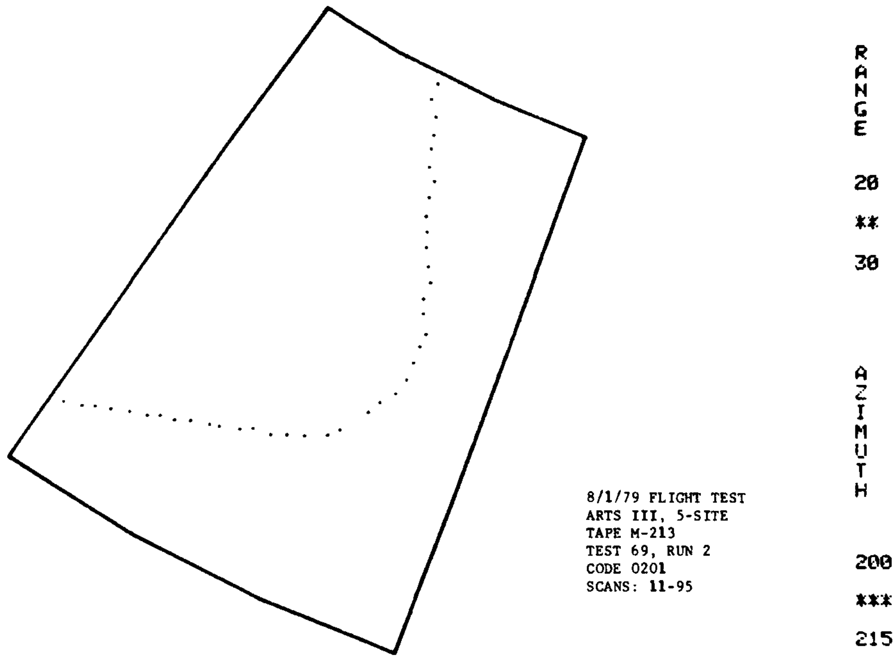
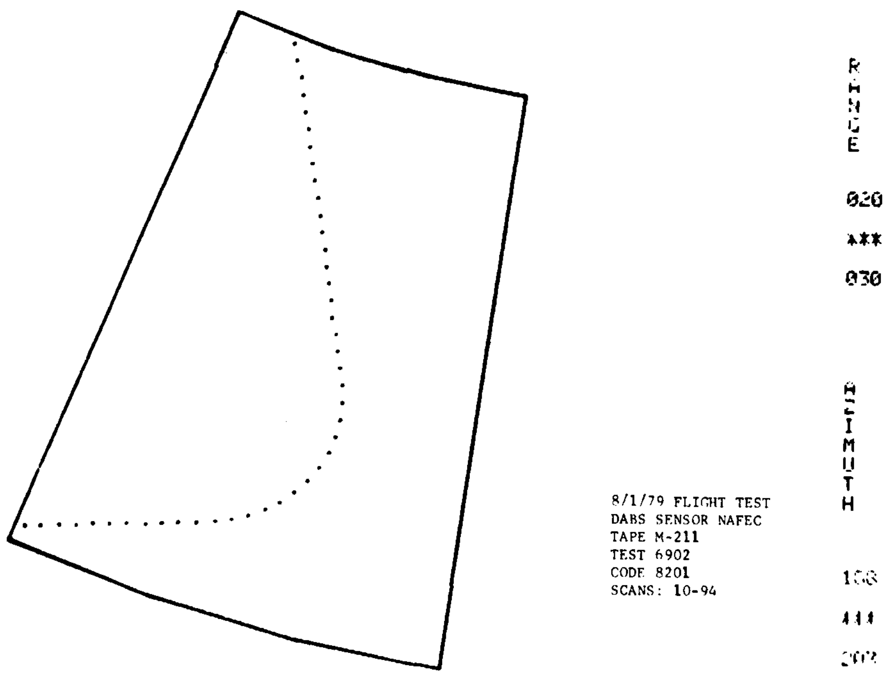


FIGURE 27. EXPANDED VIEW OF SQUARE BOX PATTERN



A. ARTS III

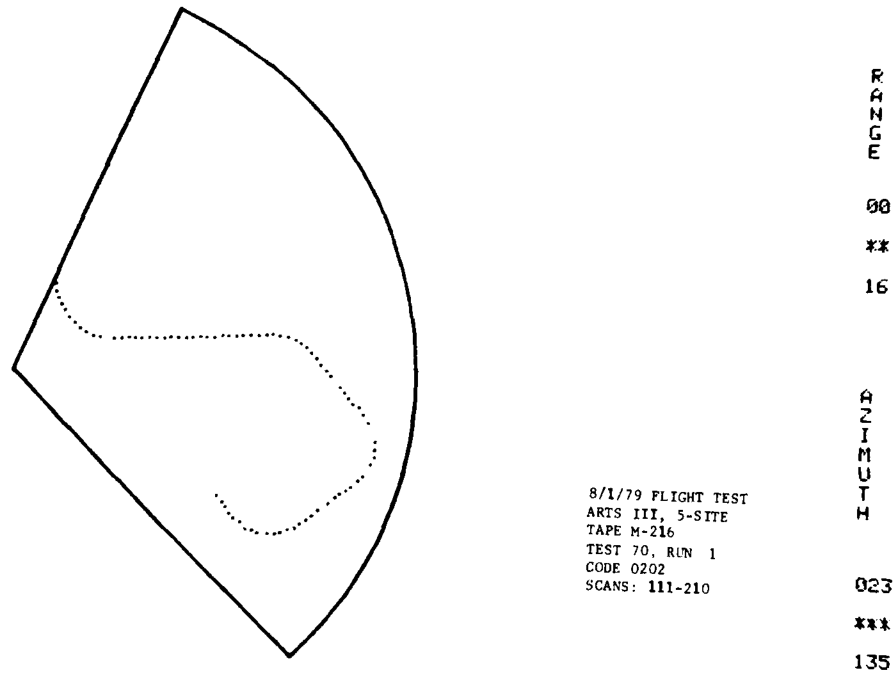
79-52-28A



B. DABS SENSOR (ATCRBS)

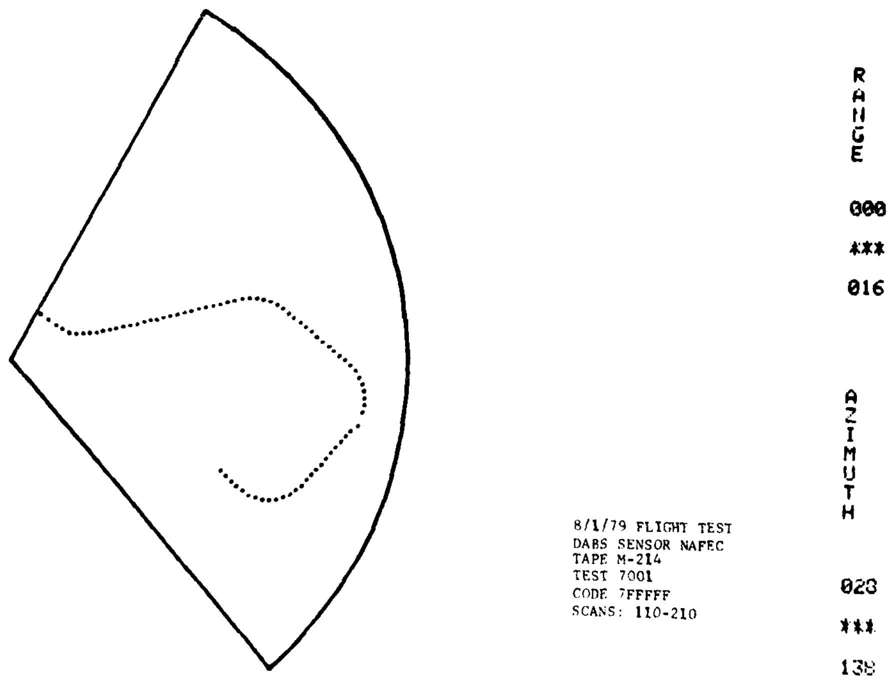
79-52-28B

FIGURE 28. EXPANDED VIEW OF TURN



A. ARTS III

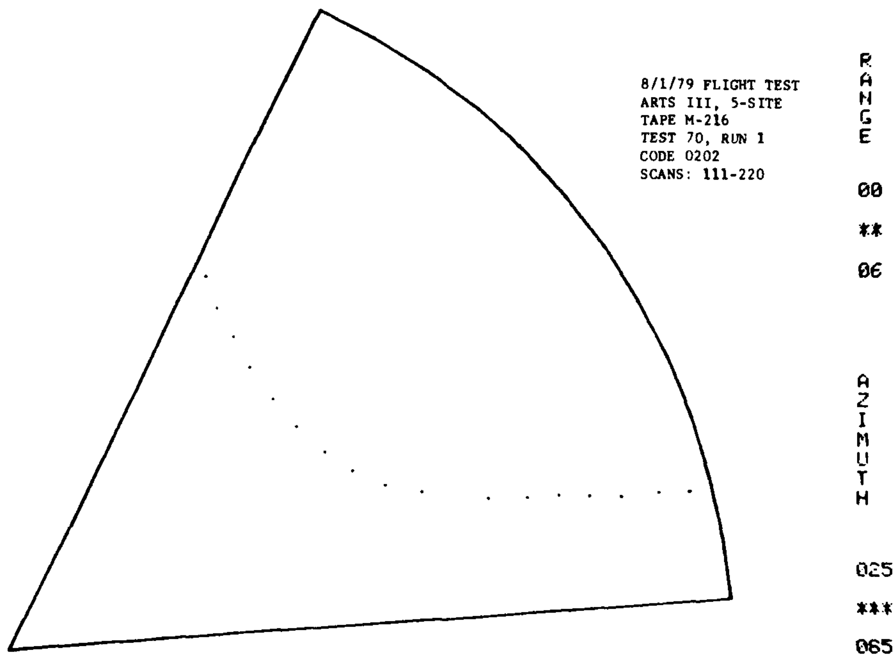
79-52-29A



B. DABS SENSOR (DABS)

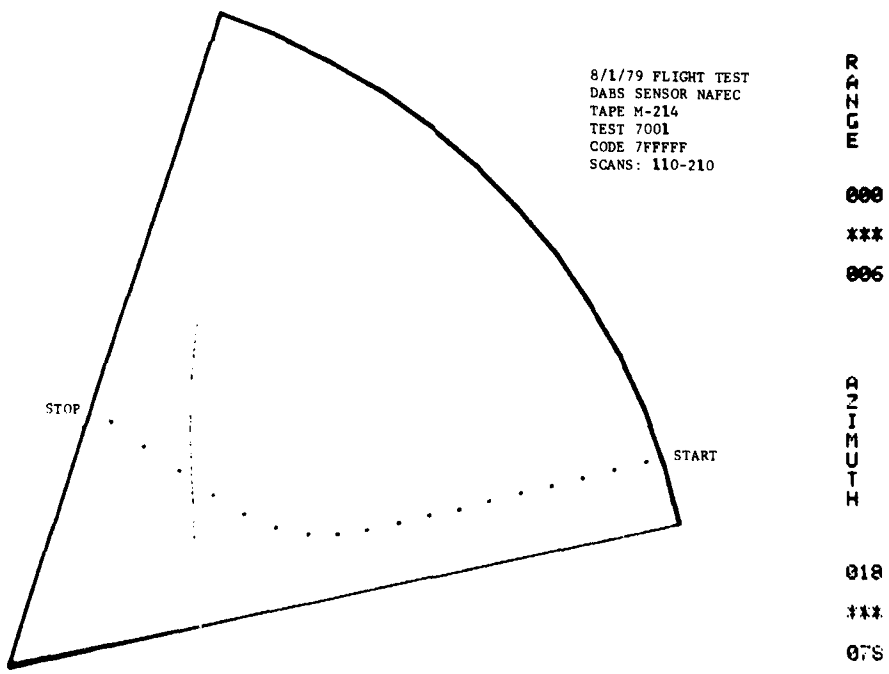
79-52-29B

FIGURE 29. EXPANDED VIEW OF MULTIPLE TURNS PATTERN



A. ARTS III

79-52-30A



B. DABS SENSOR (DABS)

79-52-30B

FIGURE 30. EXPANDED VIEW OF TURN

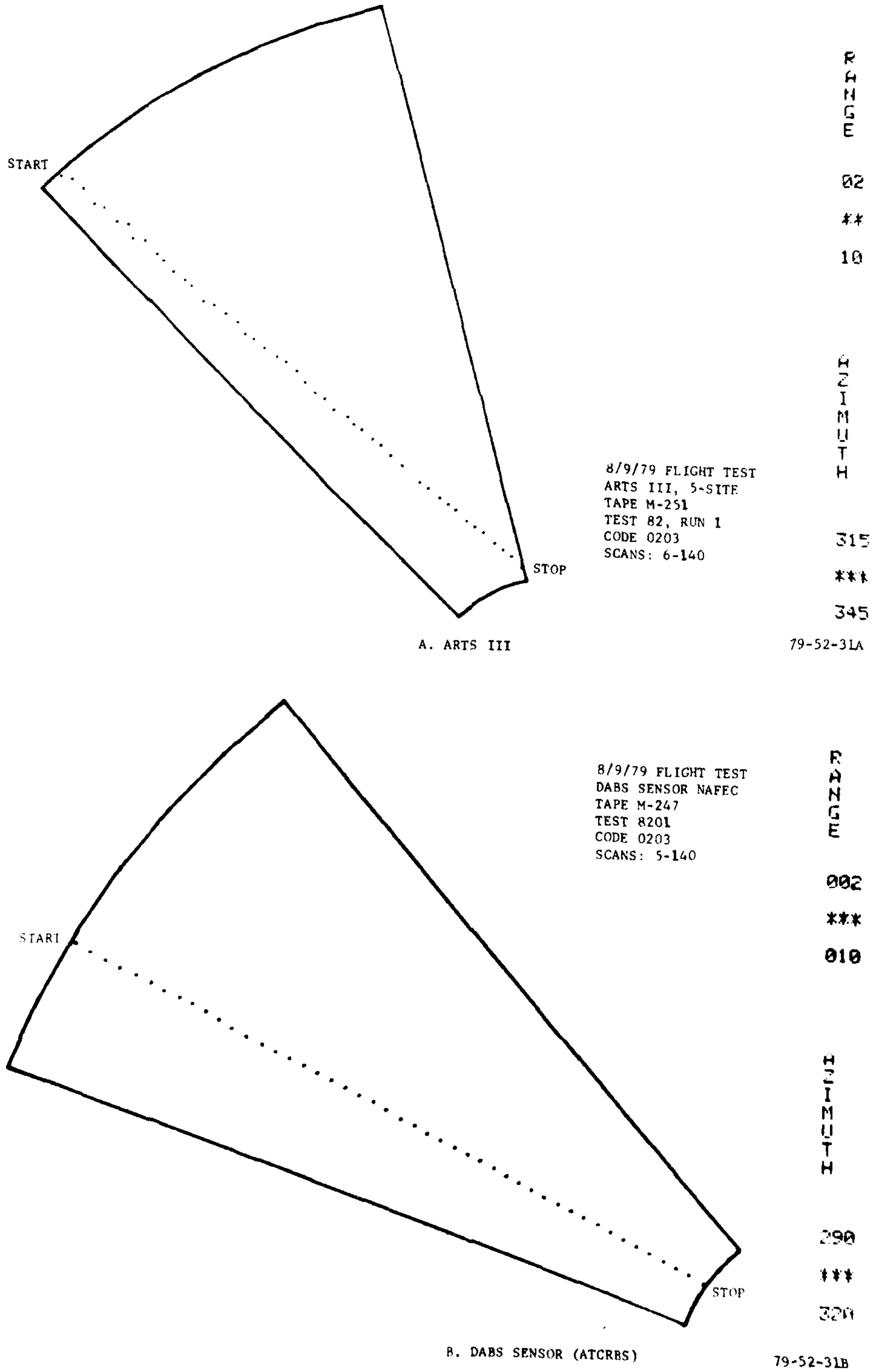
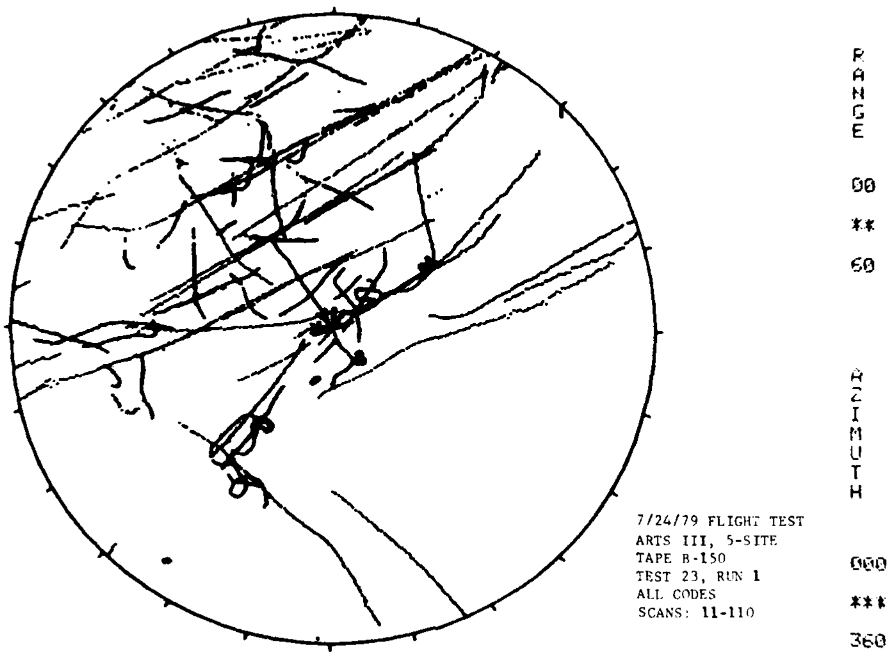
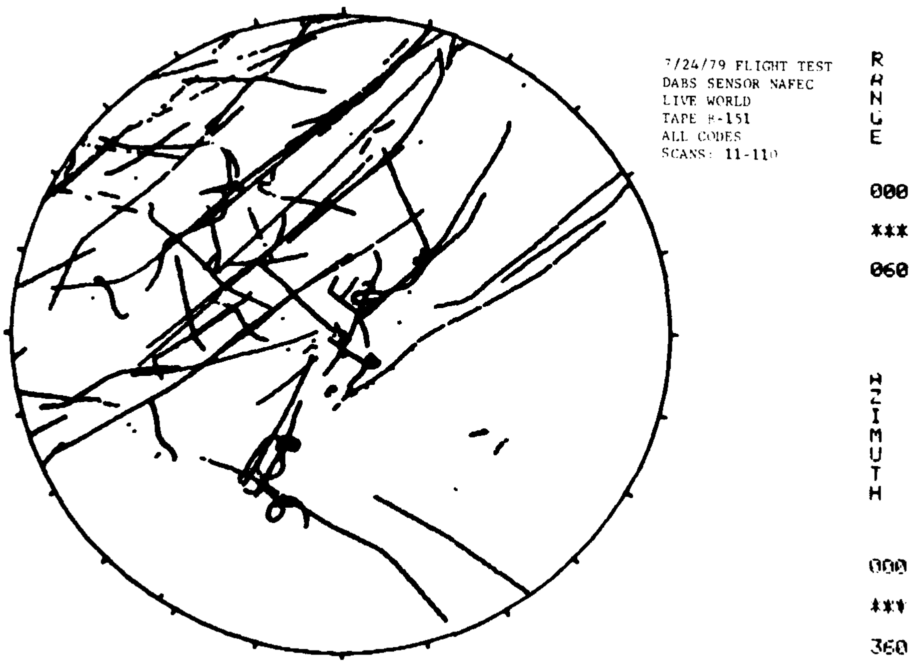


FIGURE 31. EXPANDED VIEW OF STRAIGHT LINE PATTERN



A. ARTS III

79-52-32A



B. DABS SENSOR (ATCRBS)

79-52-32B

FIGURE 32. PLOT OF TARGETS OF OPPORTUNITY

The ARTS decoded two wrong mode A-codes from the target of opportunity and two wrong mode A-codes from the test aircraft. It also appears that the ARTS had at least two misses from the target of opportunity. However, these misses, or "holes," are only apparent and were caused by extreme azimuth jitter during the crossover. The DABS sensor tracked both aircraft, figure 22b, through the crossover without a single miss or wrong mode A-code. This superior performance is believed to be due to the fact that the ATCRBS mode A-codes can be corrected by the surveillance tracker if target-to-track correlation is completed before the ATCRBS targets are extracted. This is not the case with the ARTS. The DABS track number or SFN remained the same throughout the crossover for both aircraft.

Figures 23a and b are mode C-code altitude plots of the same crossing. The NAFEC test aircraft, 4,300/4,100 feet, is assigned "□" and the real world aircraft, 5,100/4,900 feet, is assigned "X." Any other mode C-codes appear on the plots as a "•." The 200-foot difference in altitude between ARTS and DABS is because the ARTS was barometric pressure corrected and the DABS was referenced to the standard 29.92 millimeters (mm) of mercury. Figure 23a indicates that the ARTS decoded two wrong mode C-codes from the target of opportunity and one wrong mode C-code from the test or controlled aircraft. Again, the apparent "holes" were due to azimuth jitter during the crossover. Figure 23b indicates that the DABS decoded five wrong mode C-codes from the target of opportunity and five wrong mode C-codes from the test aircraft. Altitude detection in the ARTS was based on mode C-code validity, while altitude detection in the DABS was based on correct mode C-code confidence. The confidence tests in DABS require that all pulses within the code train have a high confidence. This criterion is more stringent than the validity tests in ARTS, resulting in a poorer DABS performance, with respect to mode C-code reliability for this particular case. However, 6 of the 10 low confidence DABS mode C-codes received from both aircraft were the correct altitude, but due to the low confidence, they were discarded. There was not one case for which the ARTS had correct altitude and bad validity. Disregarding the confidence/validity criteria and considering correct altitude, the DABS and the ARTS performed similarly with respect to mode C-code reliability during the crossover.

Comparison plots of a similar flight for a DABS equipped aircraft are depicted in figure 24. The DABS transponder employed an ATCRBS mode A-code of 0252 and a DABS ID of 7FFFFF. Again, the DABS track is much smoother, more solid, and had fewer misses. These misses were attributed to aircraft antenna shielding. There seems to be no discernible difference in test results when using an ATCRBS or DABS transponder in the test aircraft.

Figure 25 is comparison plots of a zenith crossing where the test aircraft was equipped with an ATCRBS transponder, mode A-code 0210. Neither site had any misses for this portion of the test except when the target was actually in the zenith cone.

Corresponding plots of a zenith crossing from another direction with a DABS transponder aircraft, ATCRBS mode A-code 0252 and DABS ID 7FFFFF, were made. Again, neither site had any misses and there was no discernible difference in test results when using an ATCRBS or DABS transponder.

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DISCRETE ADDRESS BEACON SYSTEM (DABS) BASELINE TEST AND EVALUAT--ETC(U)
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Figures 27 and 28 are a comparison plot of a flight which executed a "square box" flight pattern at approximately a 25-nmi range and 210° azimuth. The approximate altitude and speed were 8,300 feet and 240 knots, respectively. The test aircraft was using an ATCRBS transponder, mode A-code 0201. The ARTS had one miss; the DABS had no misses.

Figures 29 and 30 are a comparison plot of a flight which executed turns in both directions at ranges from 3 to 15 nmi. The approximate altitude and velocity were 8,300 feet and 240 knots, respectively. The test aircraft was using a DABS transponder, ATCRBS mode A-code 0202, and DABS ID 7FFFFF. The ARTS track had several misses, while the DABS track had only one miss, in a turn with the belly of the aircraft away from the sensors. This one miss was attributed to shielding.

Figure 31 is a comparison plot of a straight-line flight from 10 nmi out directed toward the sites. The approximate altitude and speed were 1,400 feet, ±200 feet, and 140 knots, respectively. The test aircraft was using an ATCRBS transponder, mode A-code 0203. Again, the ARTS track had one miss; the DABS had no misses.

ARTS VERSUS DABS COMPARISON—TARGETS OF OPPORTUNITY. Plots of targets of opportunity for 100 scans are presented in figure 32. A comparison of the plots for the ATCRBS mode of DABS to the ARTS indicates an approximate 10° azimuth difference. This is because the DABS system was referenced to true north and the ARTS to magnetic north. There is an approximate 10.8° declination for the geographical location of NAFEC.

A review of the plots implies that the ARTS tracks, in general, have many misses compared to the DABS. Most of the apparent misses, or holes, from the ARTS were due to azimuth and range jitter. As was seen in previous plots of controlled aircraft, azimuth jitter of the DABS was considerably less than that of the ARTS. This was due to the monopulse techniques employed in DABS. A further comparison of the two plots indicates that there are some tracks, or portions of tracks, seen by the DABS but not by the ARTS, or vice versa. Some of the more prominent cases are discussed below.

Plots of tracks, or portions of tracks, which were seen by the ARTS but not by the DABS, were analyzed. All of these targets were at low altitudes, considering their range. The low altitude, in conjunction with the additional 60-foot antenna height, explains why the ARTS site could see these targets, or portions thereof, and the DABS site could not. In every case that was investigated, where the ARTS could see tracks, or portions of tracks, and the DABS could not, altitude/antenna height was the reason.

Several plots of tracks, or portions of tracks, seen by the DABS site but not the ARTS site, were analyzed. All of the targets were of sufficient altitude to be seen by both sites. However, the tracks contain many missing reports at the DABS site and were not seen at all by the ARTS. The DABS track or SFN numbers remained the same even though the missing reports were numerous. It was verified that these targets were not reflections and it is concluded that they were "marginal" targets.

Plots of real world targets of opportunity using mode A-code 1200 are presented in figure 33. Mode A-code 1200 is used by transponder-equipped aircraft, but flying under visual flight rules (VFR). Of particular interest are those targets which are clustered, or bunched, and appear to be possible reflections. These clusters, or groups, were not reflections, but were air traffic landings and takeoffs at small airports. As indicated on the plots, the airports in question are Bader Field, Atlantic City; Manahawkin; and Ocean City, New Jersey. The ARTS also detected a similar cluster, figure 33, at Rehobeth Beach, Delaware. This cluster of targets did not have altitude encoding, but it was assumed that they were at low altitudes and could not be seen by the DABS sensor.

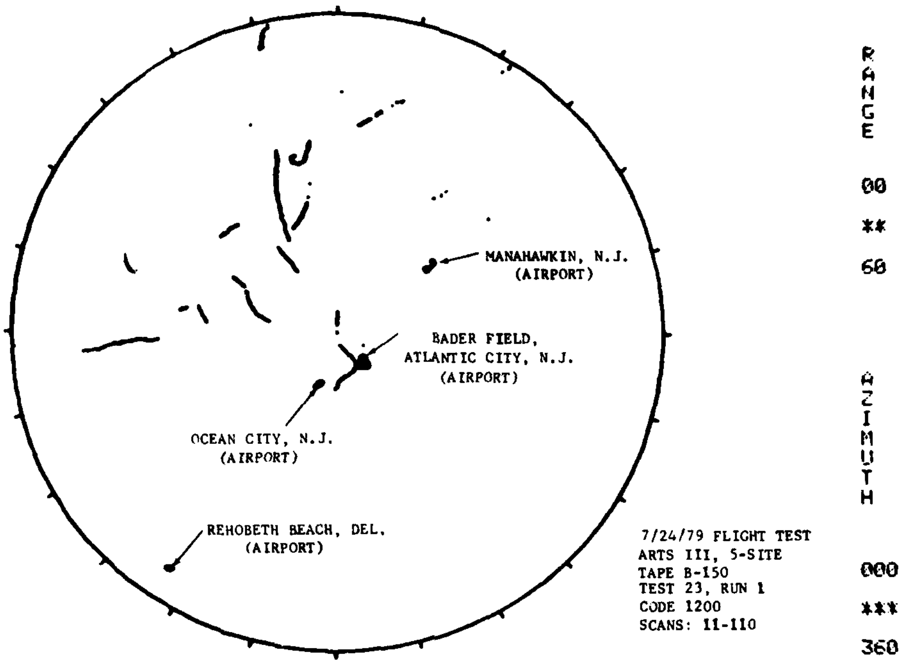
STATISTICS. In addition to the rho-theta plots, utility programs were used to generate various program listings. The program listings were used to determine certain statistical information for comparison of the two sites. The statistical information was derived from 15 scans (scans 45-59) of the real world targets of opportunity, with approximately 55 targets per scan amounting to about 800 data points. These sample scans were picked at random and did not include any of the target report misses presented earlier, with the exception of the crossover in figure 22. Overall, the real world targets of opportunity were straight tracks, or slow turning tracks, and did not have as many misses as the maneuvering controlled aircraft. The statistical results/comparisons are presented in bargraph form in figure 34.

The P_d of the real world targets of opportunity for the DABS and ARTS were 96.4 percent and 96.2 percent, respectively. These similar results indicate that both systems were performing about the same with respect to detection of targets of opportunity during the 15-scan sample. Only those real world targets of opportunity which were in constant range of the sensor were used in the P_d calculations.

The mode A-code reliability results for the DABS and ARTS were 99.3 percent and 96.5 percent, respectively. The 2.8 percent difference in favor of DABS appears to be the result of the DABS tracker updating the mode A-code. The mode C-code reliability results for the DABS and ARTS were 95.7 percent and 94.5 percent, respectively. Mode C-code was not updated by the DABS tracker; this is why there is not as much difference between mode C-code reliability results and mode A-code reliability results.

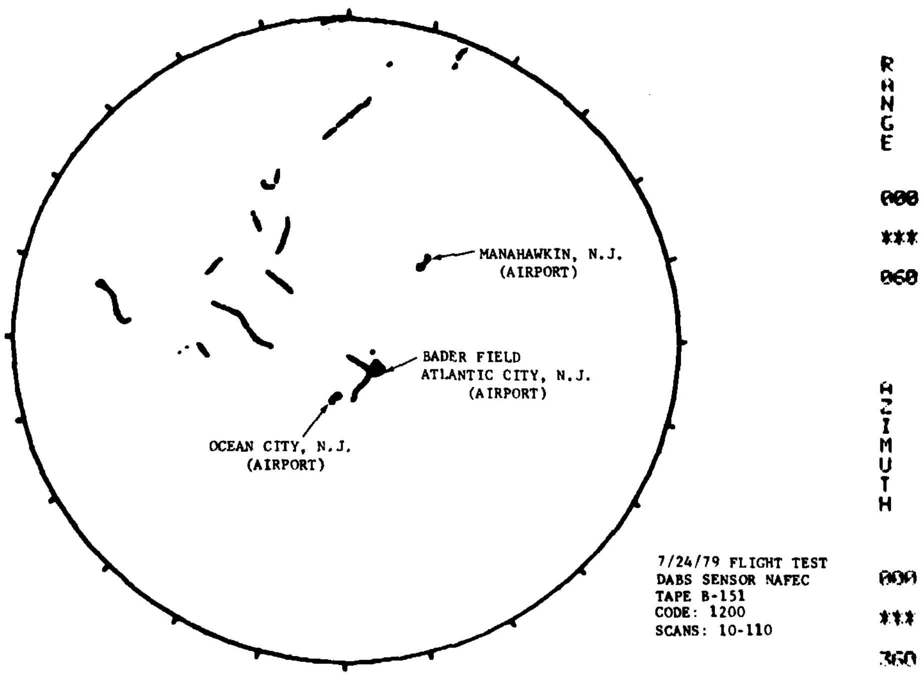
The R/R results for the DABS and the ARTS were 91.9 percent and 90.5 percent, respectively. It is noted that all targets did not have mode C-code; this data was deleted before R/R was calculated.

The number of replies per report for the DABS and the ARTS was 3.6 and 14.9, respectively. Replies per report is the area where DABS superior performance is most noticeable. The fewer number of replies per report indicated that DABS had much less spectrum pollution; the other statistics indicated that DABS had about the same or better overall performance.



A. ARTS III

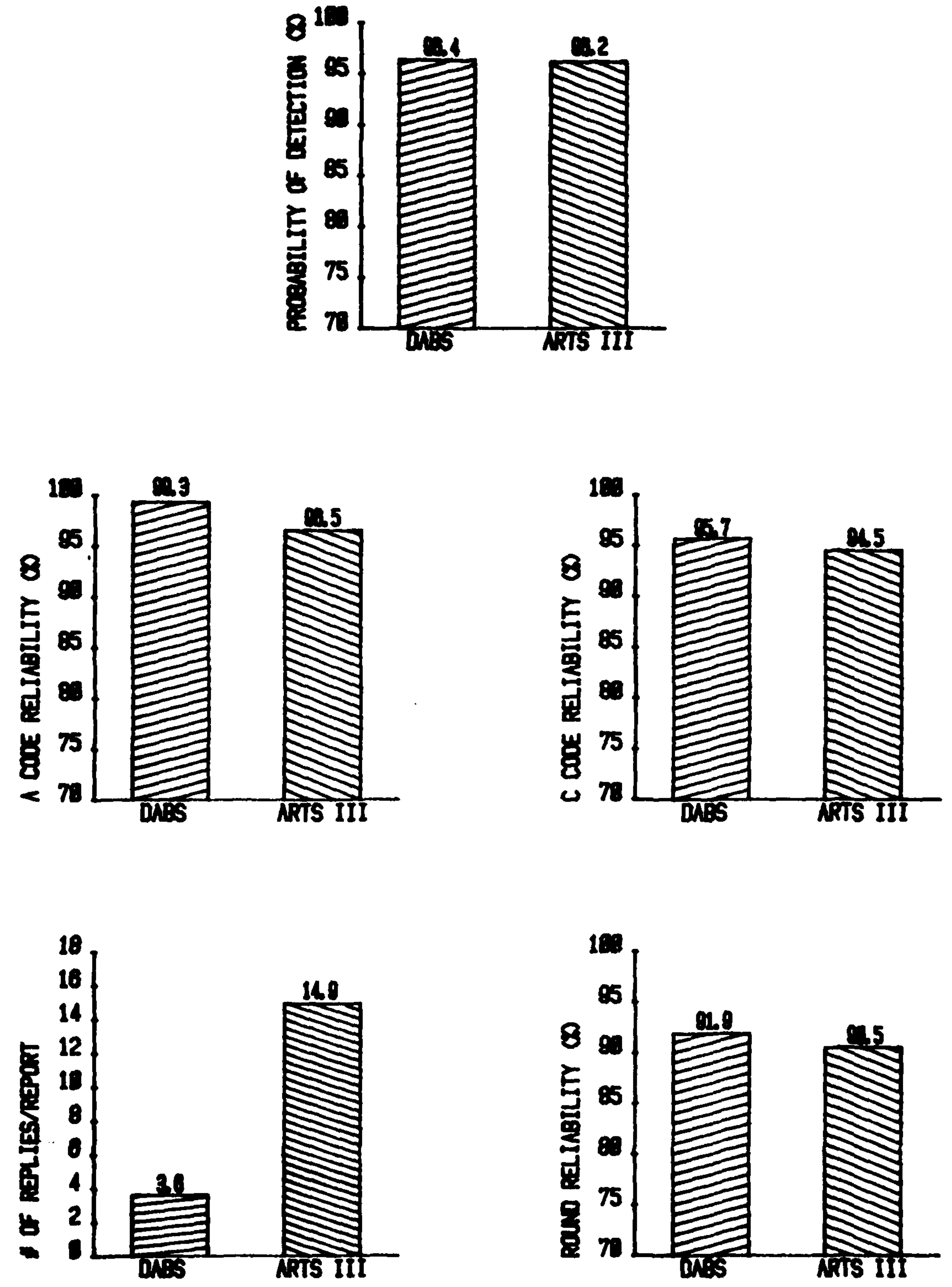
79-52-33A



B. DABS SENSOR (ATCRBS)

79-52-33B

FIGURE 33. TARGETS OF OPPORTUNITY WITH CODE 1200



79-52-34

FIGURE 34. COMPARISON OF REAL WORLD DATA FOR DABS SENSOR AND ASR-5 SITE

COMMUNICATIONS TESTS.

The purpose of communication testing was to verify the operation of the DABS communication software, as well as the link between the DABS sensor and the simulated aircraft. The performance measures evaluated include: initiation, completion, and transaction times between the sensor and simulated aircraft. The testing was performed in both a normal and capacity aircraft environment with uplink (Comm A)/downlink (Comm B) capability and ATCRBS ID request capability being tested. The transponders available for tests and ATCRBS ID did not have ELM capability (the tests did not address ELM performances). These messages will be tested at a later date.

Communication testing was performed using the Comm A/B driver and ARIES, with the Comm A/B driver (executing in a spare DABS computer) simulating an ATC facility, and ARIES simulating the aircraft. During the tests, the driver provided aircraft-destined messages to the sensor via the communication buffer at specified scans. The sensor processed the messages and stored the replies in the outgoing communication buffer. Both the incoming and outgoing communication buffers were recorded on sensor data extraction tapes, and for certain tests, an ARIES extraction tape was recorded to collect interrogation and reply data.

Analysis programs were run on the data extraction tapes. The output from these programs was used to verify that communication processing was performed correctly for each type of message.

Four different ARIES scenarios were used in the testing: basic 42-aircraft, 48 targets in 4°, 400 targets in 360°, and 282 targets in 90°. A unique Comm A/B driver message schedule was used with each scenario, except the 400 targets in 360° where the Comm A/B driver message schedule was the same as the basic 42-aircraft scenario. The following sections describe the scenarios and the associated tests and test results.

AIRCRAFT SCENARIOS AND Comm A/B DRIVER MESSAGE SCHEDULES. This basic scenario was used in six separate runs to test Comm A/B message delivery to DABS aircraft 24, 25, and 26 under varying conditions. All tests were run with 0.95 beacon R/R and 0.8 radar b/s ratio, but aircraft type and fruit rates differed, as indicated in table 12. Aircraft 24 and 25 were crisscrossing tracks, and aircraft 26 was moving in and out of the zenith cone. On various scans during the scenario, ARIES set the B-bit for these targets, simulating a pilot-initiated Comm B. The sensor requested the Comm B data and sent it to the ATC. For each of the tests run with this basic scenario, an ARIES data tape was recorded for use with the ARIES/DABS Automated Analysis Program. The driver message schedule used for the six basic 42-aircraft scenario runs indicating type of message, scan number, and aircraft identification for each message sent are shown in table 13.

TABLE 12. BASIC 42-AIRCRAFT COMM TEST RUNS

Run No.	Target Type	ATCRBS Fruit (thousand)	DABS Fruit
7	DABS only aircraft	0	0
8	Mixed DABS/ATCRBS	0	0
11	DABS only aircraft	0	50
12	Mixed DABS/ATCRBS	4	50
19	DABS only aircraft	0	200
21	Mixed DABS/ATCRBS	44	200

TABLE 13. DABS SYSTEM BASELINE TESTING COMM A/B DRIVER MESSAGE SCHEDULE BASIC 42-AIRCRAFT SCENARIO

Msg. Sched 1 Scan No.	Msg. Sched 2 Scan No.	Aircraft ID	No. Of Messages	Message Type
37	53	26	4	Comm A
67	83	26	2	Comm A
67	83	26	1	Req. For Downlink
87	103	24	4	Comm A
87	103	25	4	Comm A
97	113	26	5	Comm A
97	113	26	1	ATCRBS ID Req.
127	143	26	5	Comm A
127	143	26	1	Data Link Cap.
148	164	24	2	Comm A
148	164	24	1	Req. For Downlink
148	164	25	2	Comm A
148	164	25	1	Req. For Downlink
212	228	24	5	Comm A
212	228	24	1	ATCRBS ID Req.
212	228	25	5	Comm A
212	228	25	1	ATCRBS ID Req.
273	289	24	5	Comm A
273	289	24	1	Datalink Cap.
273	289	25	5	Comm A
273	289	25	1	Datalink Cap.

The 48 targets in the 4° scenario were used in test 26 to check Comm A/B message delivery under short-term peak loads. The Comm A/B consisted of: (1) a Comm A message to alternate DABS target per scan, and (2) a Comm B message from every tenth DABS target per scan. An ARIES data tape was recorded for data reduction and analysis purposes during the test.

The 400 targets in the 360° scenario in test 38 used the same Comm A/B message schedule as the basic 42-aircraft scenario. It was not possible to generate an ARIES data tape because of the large number of target reports generated.

The 282 targets in 90° scenario were used to validate Comm A/B performance under capacity load conditions. The Comm A/B message schedule consisted of: (1) 100 Comm A messages, to alternate DABS targets per scan; and (2) 40 Comm B messages, one from every tenth target. It was not possible to generate an ARIES data tape because of the large number of target reports.

Comm A/B RESULTS. Evaluation of Comm A/B activity for aircraft 24, 25, and 26 showed that correct replies were received for all messages sent by the driver during the six basic 42-aircraft scenario tests. The sensor responded properly during the tests when ARIES set the B-bit. The results obtained from the sensor-to-ATC messages indicated that the sensor transmitted the appropriate responses in all cases. Delays were encountered in both of the previously mentioned situations and are described below.

A total of 42 Comm A messages, in groups of three or more, was transmitted to an aircraft for the six basic 42-aircraft scenario results. Of these, 34 were delivered within one scan. There were eight cases where three Comm A's were not able to be delivered in one scan. Four of the eight cases took three scans to deliver four Comm A messages. The delay involved in transmitting these messages was not within ER specifications; these cases are being investigated. The remaining four cases occurred during the high ATCRBS and DABS fruit test in which the sensor lost several replies because of fruit garbling. In these cases it took two scans to deliver the three Comm A messages; therefore, the DABS sensor was not able to meet the requirement of three Comm A's delivered to an aircraft per scan for 10 percent of the total cases. If the number of DABS interrogations per DABS period was increased from one to two this problem will be alleviated.

All ATC-to-sensor and sensor-to-ATC message types were successfully completed. These types included the following: ATCRBS ID request and response, data link capability request and response, request for downlink data, and the message delivery or rejection or delay notice.

No Comm A/B results were obtained from the 48 targets in 4° scenario because of problems encountered in the surveillance area of the sensor under this target load. The results from the 400 targets in 360° showed that all Comm A/B messages were delivered to the appropriate destination. The results from the 282 targets in 90° showed that all Comm A's were delivered to the appropriate aircraft, and all Comm B's were received by the sensor. All ATC-to-sensor and sensor-to-ATC message types for both capacity scenarios were completed correctly.

SENSOR-TO-ATC INTERFACE TESTS.

The objectives of these tests were to determine the capability of unconditioned telephone lines to support the DABS sensor-to-ATC interface and to measure the performance of the CIDIN protocol. Specifically, the results of the interface tests are discussed in the areas of telephone lines, interface hardware, and data transfer.

TELEPHONE LINES. The data collected during the testing of the characterisitcs of the dedicated telephone lines installed for interfacility data transfer were reviewed and plotted. Sample plots for the NAFEC and Elwood sensor lines are shown in figures 35 and 36. These figures show signal attenuation relative to signal delay and frequency translation for one telephone line for each sensor tested. Copies of plots for all lines tested are available for review at NAFEC.

As of September 1979, the telephone lines for the Clementon sensor were in the process of being checked and repaired by the telephone company following damage believed caused by lighting strikes. Tests of these lines will be accomplished following the completion of this report and results will be included in a future report.

All line parameters measured have been found to be within the limits specified for type 3002 unconditioned lines.

During the interface test period, these lines were used with the 4800 bps codex LSI 481 modems supplied by TI with a minimum of problems. In those cases where problems occurred, they were attributed to the line characteristics being out of specification.

It should be noted that during the preliminary tests, some problems were experienced with telephone lines drifting to a marginal condition, as detected by the receive modems. Inspection by the telephone company revealed that the lines in question were slightly out of specification. However, they also detected that the modem output level was down 6 dB. A check of the modem revealed an internal switch which allowed the transmit level to be adjusted to produce up to a 12 dB loss. It was found that all DABS modems had been set at the factory for a 6 dB loss. These were changed to a 0 dB loss and no further problems were experienced with line drift.

INTERFACE HARDWARE. No problems were experienced during the test period with the interface hardware design.

DATA TRANSFER. Information on the transfer of data across the interface from the sensors to the two NAFEC ATC facilities (SSF and TATF) were collected by utilizing the ATC facility interface software. Much of this testing was accomplished during the preparation for, and conduct of, the sensor field acceptance tests.

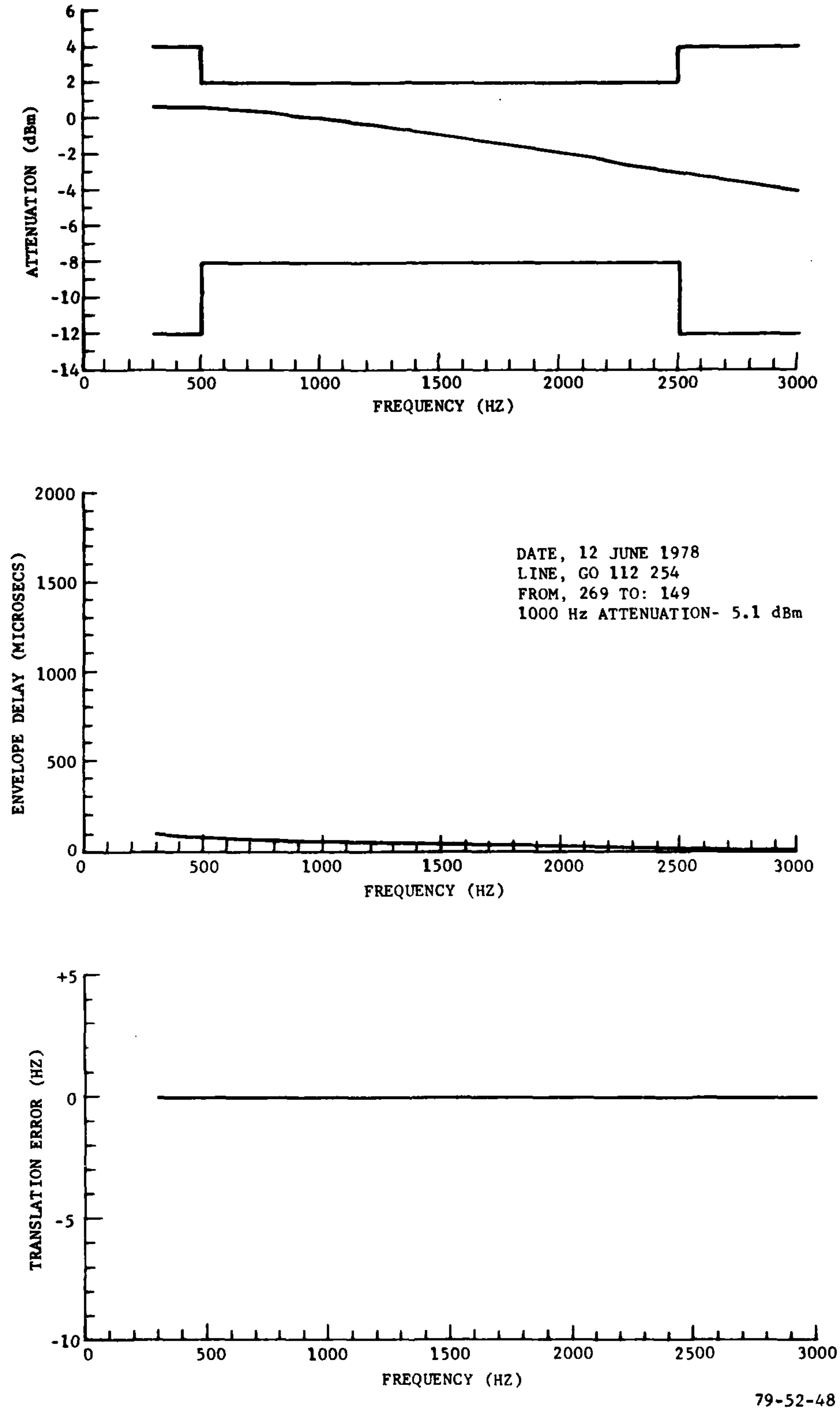


FIGURE 35. LINE CHARACTERISTIC CURVES FOR LINE GD 112 254 (NAFEC SENSOR TO SSF SURV CHAN 1)

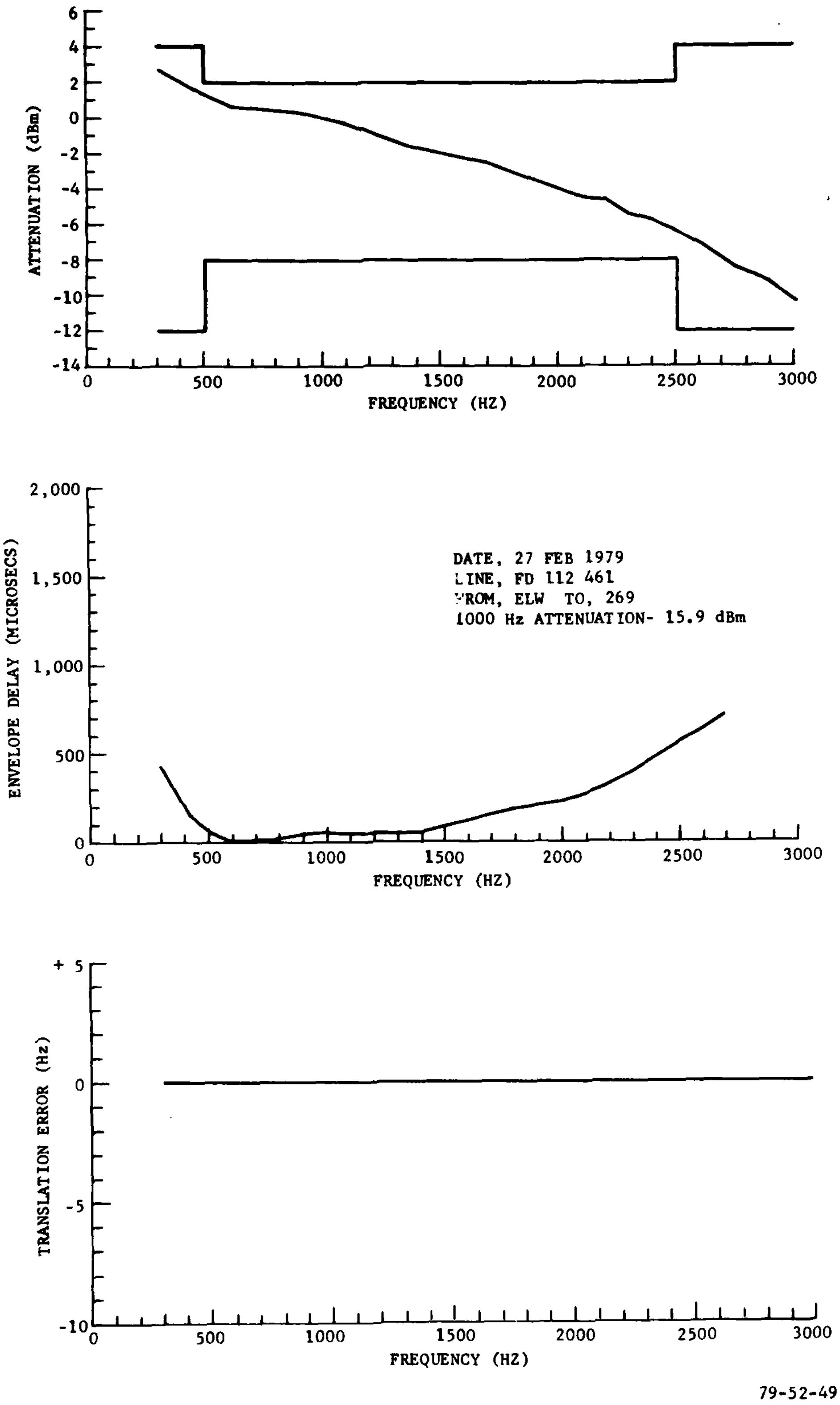


FIGURE 36. LINE CHARACTERISTIC CURVE FOR LINE FD 112 461 (ELWOOD SENSOR TO NAFEC SENSOR CIDIN CHAN 1)

For the surveillance interface, data transfer rates ranged from a minimal to near line capacity with input loads ranging from 40 input targets to the high capacity load of the L.A. Basin. No problems were experienced with data transfer on this interface.

For the communication interface, data transfer rates varied from minimal (one status message per scan with no scenario) to the heaviest load supportable with the interface verification software (10, 104-bit tactical uplink messages per second). Although, in general, testing revealed that data transfer was adequate.

During this period several problems were experienced with the communications interface. The problems were divided into four main areas: message structure, 9020/FEP protocol, CIDIN protocol, and message transfer loss.

1. Message Structure. During the testing, several message types were found to exceed the bit length specified in FAA-RD-74-63B. Each of these messages contained eight extra zero bits added to the end of the message.

The error was caused by an incorrect message length field being passed to the CIDIN computer by the sensor program originating the message. All of these have been corrected with the exception of the track alert message, type code 9c. The track alert messages are still received with the extra eight bits. Once the length errors had been corrected for all other messages, it was discovered that this error type (i.e., eight extra zero bits) occasionally occurred. These errors appeared to be random and occurred on various types of codes. It was learned that this problem had been detected by TI during factory testing of the Clementon sensor with the communication test unit (CTU). The problem had been traced to an error in the control programmable read only memory (PROM) for the communication interface board. This problem is currently being corrected by replacement of the existing PROM's.

Throughout the test period it was observed that messages, which elicited a response from the sensor, were occasionally not answered even though a CIDIN accept was received for the message. This problem was most frequently observed for sensor test messages for which no sensor test response messages were received. This lack of response, at times, was repetitive; if the message source was from a scenario tape in the TATF, the error would always occur for the same test message, and for each time that scenario was executed. However, if the identical message was entered manually, the error would not occur.

It has been observed that the sensor reported receipt of an unknown message at the time a message was received for which no response message was generated. The discarded message was found to be the request message containing an extra eight bits. It is probable that the loss-of-response problem was also caused by the PROM error; and once the PROM is corrected, the lack-of-response problem will disappear.

One additional problem of this type was the receipt by the 9020 of messages containing erroneous data. During the Elwood field acceptance test, this was typified by receipt of a test response message which did not match the test message preceding it. Additionally, status messages were frequently received with an erroneous number of error code fields. This problem has been traced to a software error in the FEP. When a message in the FEP CIDIN input buffer overlapped the end and the start of the buffer area, the first part of the message was correctly picked up from the buffer for transfer to the DCU buffer and sent to the 9020. However, the remainder of the message was not retrieved from the start of the buffer, but from the address space which followed the last word of the buffer. This is currently under investigation by TI software personnel.

2. 9020/FEP Protocol. Two problems have been observed with the existing protocol for transfer of data between the 9020 and the FEP. The first involves FEP initialization, and the second involves message retransmission on message length errors.

An FEP initialization message from the 9020 to the FEP does not, in fact, cause initialization of the FEP, but only initializes the interface between the 9020 and FEP.

When the 9020/FEP interface is down, the FEP buffers all messages received from the sensors. If a buffer overflow occurs, the oldest messages are overwritten, and the buffer pointer is updated accordingly. When the FEP receives the initialization message from the 9020, it replies with an initialization response message and proceeds to transfer all of the stored messages in its buffer to the 9020. The FEP buffer is approximately 2,000 bytes in length. The 9020 can receive a large number of these messages immediately following startup. Additionally, these messages do not contain any time reference; the 9020 has no way of knowing how old these messages are.

The 9020 cannot determine when transfer of buffered data ends and transfer of current data begins. If the 9020/FEP interface has been down for several hours, the 9020 has no way of determining if messages received following interface initialization refer to current traffic situations or occurred immediately following loss of the interface.

Currently, this problem is being partially bypassed by manually reinitiallizing the FEP software prior to each run with the 9020. This destroys any messages which may be buffered within the FEP. However, it appears that a means to invoke FEP initialization from the 9020 is required. This could be accomplished either through a redefinition of the current initialization message, or through definition of a new message (i.e., FEP startover) which would cause the FEP to reinitialize all its buffers.

The second FEP/9020 protocol problem involves the requesting of message retransmission following receipt by the 9020 of a message with a length error. As currently defined, two distinct types of length errors were detectable on the FEP/9020 interface. The first occurred when the length of the message transmitted over the interface did not match the length contained in the header word. This error normally indicated a transmission error which can possibly be corrected by retransmission.

The second error occurred when the message length did match the header, but did not match the expected length for the message type. Retransmission by the FEP of this message will result in the identical message with the same error being received by the 9020.

The existing specification for the FEP/9020 protocol specifies that for both of these errors the 9020 shall request retransmission. It further specifies that if the following message also contains an error, retransmission of the next expected message will be requested.

This resulted in two requests for retransmission every time an erroneous message was received by the FEP from the sensor. The first was for a message sent, and the second, ignored by the FEP, was for a message not yet sent to the 9020. Additionally, the FEP was required to timeout the retransmitted message because no response to it was ever received by the FEP.

In light of the fact that an error of this type cannot be rectified by retransmision, it was felt that these messages should be rejected rather than a retransmission requested. This should greatly reduce the overhead proccessing required by both the FEP and the 9020.

3. <u>CIDIN Protocol</u>. Three problems have been identified with the current implementation of the CIDIN protocol: (a) system startup, (b) processing of an accept reply to an enquiry for a lost message, and (c) enquiry message processing delay.

At system startup, the CIDIN software initialized its transmit and receive message numbers to zero and began transmitting RESET commands. The opposite system recognized the RESET and sent an ACCEPT 255 to acknowledge receipt. This established the outbound link. Unless the opposite system had recognized that a link outage had occurred, the inbound link could not be established.

When the opposite system transmits a message, it will most likely have a number other than zero, provided that a link has been established in the past. This message will be rejected for lack of a valid message number. The resulting reject message (N2QN) will have a reference message number of zero, indicating that the next expected message should have a message number of zero.

The CIDIN protocol, however, specifies that response messages must be valid in order to be recognized. This means having a message number which is expected. As a message number of zero is not expected, the response is ignored and the message times out. As specified, three enquiry messages are then sent with their respective responses being ignored before system recovery is called, a RESET message is transmitted and the link reestablished.

As the timeout parameter (t_r) is currently set to 3 seconds, the reestablishment of the link requires 12 to 15 seconds following transmission of the original message.

The impact of this problem could be minimized by reducing the timeout period. Current experience indicates that responses to messages from the TATF are received in less than 0.1 seconds. An analysis of the worst-case message length indicates a timeout of 1 second may be adequate. (It should be noted that a timeout period of over 0.5 seconds is needed only for the accommodation of ELM messages.)

Several solutions are as follows:

a. Recognize the reject for message number error with a reference message number of zero. Whenever this condition exists, system recovery is entered immediately. A RESET message will be sent immediately rather than waiting for successive timeouts to cause system recovery.

b. Investigate the possibility of causing the communication interface board to remain in a reset condition throughout the period of a system load. This would ensure that the flag (idle) character string is broken and recognized by the other CIDIN center. If a RESET is received following this line outage, a RESET will be sent to ensure link establishment prior to attempting to transmit other messages.

c. Define a special message to be transmitted following system load requesting link reestablishment.

Further analysis of this problem is required, in conjunction with a study of the changes which have been made by ICAO to the CIDIN protocol, before a definitive recommendation can be made.

The second CIDIN problem involved the use of enquire messages. By protocol, as described above, response messages are recognized if they are valid. As currently programmed, the receipt of a response message to an enquire indicating that the message in question was not received, is not recognized as valid and is ignored. For example: message number 9 was transmitted and accepted, message number 10 was transmitted and no response received. When an enquire was sent for message number 10, an accept for message 9 was received. This indicates that the last received message was number 9. However, as this response was not expected (message 9 is not outstanding), it was considered invalid and ignored. Two additional enquires were sent and timeout and RESET messages sent to reestablish the link.

Following transmission of an enquire message, the receipt of an accept message for the last accepted message should be considered valid and indicate that the following messages be retransmitted. Ignoring this response only lengthened the recovery period.

The third CIDIN problem noted also involved the enquire message. The CIDIN protocol specifies that the response to an enquire message must be sent as soon as possible. It has been observed, however, that these responses currently require 6 seconds. As protocol responses (i.e., accepts and rejects) require less than 0.1 seconds, and test response messages are received in less than 0.1 seconds after transmission of the test message which elicits them, this delay is not understandable. Furthermore, as the timeout period for an enquire is supposedly 3 seconds, at least two enquires are sent before the first response is received. This delay only adds a further degradation to the problem of dealing with responses to enquires for messages which have been lost.

4. Message Transfer Loss. Two problems have been observed which result in the loss of message transfer capability. The first of these involves transfer of data from the 9020 through the FEP to the sensors, while the second involves loss of high priority messages to all ATC facilities when the CIDIN link to one facilty is lost.

In the first case, it was found that if two messages were sent to the FEP within approximately 15 seconds of each other, and there was a need to reestablish the CIDIN link, as discussed above under CIDIN protocol, the processing of CIDIN transmit messages by the FEP would terminate. No messages from the 9020 were forwarded to the sensor after the link reestablishment, except for the first message on which the FEP discovered the link outage.

This problem appeared to happen only if the second message was received while a link reestablishment cycle was in progress. If the link reestablishment was accomplished prior to receipt of the next message, no problem existed.

This is currently under investigation by TI personnel. To date, this is only known to have caused problems at system startup time when the two systems contain different message numbers. This can be minimized by causing either a warm start or cold start of the FEP, prior to 9020 startup, if the sensor has been reloaded. However, this situation would also occur if a CIDIN message was lost and the accept to an enquire ignored.

The second message transfer loss problem involved loss of messages from the sensor high priority output queue. As currently designed, the CIDIN computer will not discard a message from the high priority output queue under any circumstance. If either of the two existing ATC facility CIDIN links were lost, messages continued to be processed to the other. If a message for the failed facility was left in the high priority message queue, however, high priority messages continued until the circular buffer wrapped to the point where this message first entered the queue. As this message must be kept, it was not overwritten, and processing of all high priority queue messages to all facilities halted until the original failed facilty link was reestablished. When this occurred, the offending message was transmitted, the buffer released, and all missing messages released and transmitted.

Further investigation is required into the handling of high priority messages, and how these may be retained when a link fails, without halting transmission of other high priority messages to other facilities.

RELIABILITY.

The purpose of the reliability evaluation of the DABS sensors was to ascertain any weak points or problem areas in the system design. These would manifest themselves by the occurrence of distinct or repetitive hardware failure patterns, as well as by unusual difficulties encountered in diagnosing, isolating, and correcting these failures.

The evaluation consisted of recording each hardware failure that occurred in the NAFEC sensor from June 30, 1978, until July 23, 1979. These dates correspond, respectively, to the first recorded failure and the first of three severe thunderstorms which caused extensive equipment damage. These failures were then grouped according to the reliability elements in which they occurred, and further categorized according to failure type. The 22 different types of reliability elements were determined by physical, functional, and redundancy considerations.

Using computerized mathematical models; element type, subsystem, and system failure rates were computed for the periods October 1, 1978, through April 30, 1979, and May 1, 1979, to July 23, 1979. The April 30 date corresponds to the replacement of the original DABS antenna with the ATCRBS 5-foot antenna type. These computed failure rates were compared with the corresponding predicted values to further identify the location of problem areas.

Data were collected from two sources. One of these was the Facility Maintenance Logs (FAA Form 6030-1) upon which failure and maintenance data, as well as changes in operational status, were recorded by FAA DABS site personnel. These log forms were maintained as of September 20, 1978. The other source of failure data consisted of the DABS Trouble Reports maintained by TI's site personnel. These provided detailed information on failures and date from June 30, 1978, the date of the first recorded failure.

From the above two sources, each failure incident and change in operational status was associated with the proper reliability element and encoded for processing on the Honeywell Computer by the ARAP. The ARAP was a set of computer programs specifically developed to process and present the failure, maintenance, and operational status history of the various hardware elements which comprise a system. ARAP printouts were generally obtained for each month's activity.

Data were obtained on a total of 226 reliability elements comprising 22 different element types. These are shown in table 14. Each hardware failure was assessed to determine whether or not it was to be considered as chargeable. For the purpose of this report, a failure is considered as chargeable if it: (1) is independent, that is, it did not occur as a result

TABLE 14. RELIABILITY ELEMENTS COMPRISING DABS SENSOR

Element Type	No. Evaluated
1. Air Conditioner	1
2. Antenna	1
3. Channel Transfer Unit	1
4. Transmitter	1
5. Receiver	1
6. Processor (Including ATCRBS and DABS)	1
7. WWVB Receiver (Including Uninterruptable Power Supply)	1
8. Tilines	12
9. Couplers	47
10. Interface Printed Circuit Boards (PCB's)	5
11. +5-Volt Triplex Power Supplies	36
12. $\pm$ 12-Volt Power Supplies	4
13. 12-Volt Power Supply Common	1
14. DABS Computers	36
15. 176K Memories	6
16. Memory Monitor Switching Element (Part of Memory Monitor PCB)	4
17. Memory Monitor Serial Element (Part of Memory Monitor PCB)	4
18. Communications Interface Serial Element (Part of Communications PCB)	15
19. Communications Interface Channel Element (Part of Communications PCB)	30
20. Modems	16
21. Link Switches	2
22. Primary Radar Interface	1

of a previous failure or a hardware modification; (2) caused a loss or degradation of performance of the DABS element in which it occurred; or (3) required actual maintenance effort to correct.

A failure is considered nonchargeable if it: (1) resulted from factors external to the equipment under test (i.e., failures of commercial power, etc.), (2) resulted from personnel error, or (3) resulted from manufacturing or wiring defects which, when corrected, preclude the possibility of recurrence.

Defective parts in the circuitry of an element, discovered as a result of diagnostic programs or procedures applied during regularly scheduled preventive maintenance time, were considered as chargeable failures if the above criteria are met.

Tables 15, 16, and 17 are sample ARAP printouts showing operational status summaries, element hardware failure summaries, and part failure summaries, respectively. In table 15, the "U" and "C" columns indicate the total uptime and total repair times, respectively, for each hardware element for the time interval covered. The "TOT U" and "TOT C" columns show these quantities for each element type. In table 16, failures which were determined to be nonchargeable are indicated by the letter N inserted before it.

Frequent consultations concerning the reported failures were held between NAFEC and TI personnel in order to determine the chargeability of these failures, and insure optimum accuracy of the reported information, including the best estimate of repair times.

In summary, 95 hardware element failures were recorded between June 30, 1978, and just prior to the first thunderstorm which occurred on July 23, 1979. These failures are documented in the ARAP printouts available at NAFEC. Of these 95 failures, 54 were determined to be chargeable.

Table 18 shows the distribution of these 54 chargeable failures among the reliability elements. Of these, 22 occurred in the DABS computers. The main failure pattern among the computers was voting errors, of which there were 13. Nine of these 13 voting errors were due to defective arithmetic unit (AU) printed circuit boards (PCB's) or their connectors, two were due to defective local memory PCB's, and one was due to a defective voter PCB. Each DABS computer consists of two AU PCB's, one voter, and one local memory PCB.

The next highest number of chargeable failures (six) appeared in the modems. The major failure pattern in the modems appeared to be data errors.

Two of the three transmitter failures involved the cooling fan to the traveling wave tubes (TWT's) or the TWT air flow sensing switch. These two failures occurred during the first part of the reporting period (up to January 1979), and were caused by an inappropriate air sensing configuration. The air sensing vane has been identified as an item for future design improvement.

TABLE 15. DABS SYSTEM NAFEC—ELEMENT STATUS TIME SUMMARY—PART 2 PERIOD 4/1/79 TO 4/30/79

STATUS TIME (HRS.)

ELEMENT TYPE	LOC	ELEMENT NO	U	TOT U	O	TOT O	C	TOT C	E	TOT E
ANTENNA	NAFC	1	620.58	620.58	52.58	52.58	3.08	3.08	43.75	43.75
CHANNELXFR	NAFC	2	691.67	691.67	28.33	28.33	0.	0.	0.	0.
TRANSMITTR	NAFC	3	627.08	627.08	92.33	92.33	0.58	0.58	0.	0.
RECEIVER	NAFC	4	687.58	687.58	28.58	28.58	3.83	3.83	0.	0.
PROCESSOR	NAFC	5	691.67	691.67	28.33	28.33	0.	0.	0.	0.
WWVB RECVR	NAFC	6	691.67	691.67	28.33	28.33	0.	0.	0.	0.
TILINE	NAFC	7	691.67		28.33		0.		0.	
TILINE	NAFC	17	691.67		28.33		0.		0.	
TILINE	NAFC	27	691.67		28.33		0.		0.	
TILINE	NAFC	37	691.67		28.33		0.		0.	
TILINE	NAFC	47	691.67		28.33		0.		0.	
TILINE	NAFC	57	691.67		28.33		0.		0.	
TILINE	NAFC	67	691.67		28.33		0.		0.	
TILINE	NAFC	77	691.67		28.33		0.		0.	
TILINE	NAFC	88	691.67		28.33		0.		0.	
TILINE	NAFC	115	691.67		28.33		0.		0.	
TILINE	NAFC	134	691.67		28.33		0.		0.	
TILINE	NAFC	151	691.67	8300.00	28.33	340.00	0.	0.	0.	0.
COUPLER	NAFC	8	691.67		28.33		0.		0.	
COUPLER	NAFC	9	691.67		28.33		0.		0.	
COUPLER	NAFC	18	691.67		28.33		0.		0.	
COUPLER	NAFC	19	691.67		28.33		0.		0.	
COUPLER	NAFC	28	691.67		28.33		0.		0.	
COUPLER	NAFC	29	691.67		28.33		0.		0.	
COUPLER	NAFC	38	691.67		28.33		0.		0.	
COUPLER	NAFC	39	691.67		28.33		0.		0.	
COUPLER	NAFC	48	691.67		28.33		0.		0.	
COUPLER	NAFC	49	691.67		28.33		0.		0.	
COUPLER	NAFC	58	691.67		28.33		0.		0.	
COUPLER	NAFC	59	691.67		28.33		0.		0.	
COUPLER	NAFC	68	691.67		28.33		0.		0.	

STATUS CODE DESCRIPTIONS

U- POWERED UP AND BEING USED OR AVAILABLE FOR USE
C- CORRECTIVE MAINTENANCE INCLUDING FAULT ISOLATION, REPAIR AND VERIFICATION
E- ENGINEERING CHANGES INCLUDING INSTALLATION OR REMOVAL AND CHECKOUT
O- POWER OFF EXCLUSIVE OF CORRECTIVE MAINTENANCE AND ENGINEERING CHANGES

TABLE 16. DABS SYSTEM NAFEC — ELEMENT HARDWARE FAILURE SUMMARY PERIOD 4/1/79 TO 4/30/79

DABS SYSTEM

NAFEC

ELEMENT HARDWARE FAILURE SUMMARY

PERIOD 4/ 1/79 TO 4/30/79

ELEMENT TYPE	LOC	ELEMENT NUMBER	YRMODA	HRMN	FAILURE DESCRIPTION	DOWN TIME (HRS)	OFFLINE REPAIR (HRS)	PART IDENTIFICATION (NO./TYPE/LOC.)	DISPOSITION
(S) AIR CONDIT	NAFC	301	790421	1800	FAILED	1.0	0.		
(S) ANTENNA	NAFC	1	790410	1400	ASR-7 ANT. DRIVE CONTROL CIRC. FAIL	3.1	0.	SHORTED BRAKE RELEASE SOLENOID. TEMPORARILY FIXED BY REMOVING 120V TO SOLENOID AND ADDING HOLD-OUT BRACKET ON ANT. DRIVE MOTOR BRAKE RELEASE LEVER TO DISENGAGE ANTENNA BRAKE MECHANICALLY.	REPLACEMENT ASR-7 BRAKE ASSEMBLY ORDERED. REPLACED APRIL 25TH.
(N) TRANSMITTR	NAFC	3	790409	800	SLS TWT FILAMENT FAULT	0.1	0.	POWER TRANSIENT. CLEARED	ON RESET.
(N) TRANSMITTR	NAFC	3	790416	800	SLS TWT FILAMENT FAULT	0.1	0.	CLEARED ON RESET.	
(S) RECEIVER	NAFC	4	790416	810	SOLID FAILURE IN IF SUM LOG AMPLIF.	0.	0.	DEFECTIVE SOLDER JOINT. VR-5 ZENER DESTROYED AND Q23 AND Q24 REPLACED DURING REPAIR.	REPAIRED LOG. AMPLIFIER PCB 1A3A1A1.
+5-V. P.S.	NAFC	75	790430	810	POWER SUPPLY RAN HOT.	0.5	0.	DEFECTIVE COOLING FAN.	REPLACED FAN.
(N) COMPUTER	NAFC	11	790405	810	HUNG UP TWICE DURING HSMAT TEST	1.0	0.	INTERCHANGED VOTER PCB	WITH CPU 3E
COMPUTER	NAFC	23	790410	810	VOTED SOLID AT START OF HSMAT	1.2	0.	EXCHANGED AU-1 PCB AT SLOT 10A1A21 WITH PCB FROM ELEMENT 42, WHICH HAD BEEN VOTING INTERMITTENTLY FROM MARCH 20. ELEMENT 23 CONTINUED FREQUENT VOTING DUE TO BAD AU-1 FROM ELEM. 42	ON APRIL 22, REPLACED BAD AU-1 (FROM 42) WITH AU-1 PCB FROM ELEMENT NO. 43. 42 NOW OK, 43 NOW NG.
COMPUTER	NAFC	43	790422	2220	VOTED FOLLOWING POWER OUTAGE.	1.0	0.	DEFECTIVE AU-1 BOARD. SWAPPED BOTH AU-1 PCB'S WITH ELEMENTS 23 AND 42. CONTINUED INTERMITTENT VOTING.	
MODEM	NAFC	217	790413	800	INTERMITTENT BAD RECEIVER MESSAGES	0.3	0.	RANDOM OCCURRENCES. WILL	CALL CODEX.

TABLE 17. DABS SYSTEM NAFEC PART FAILURE SUMMARY PERIOD 4/1 79 TO 4/30/79

PART IDENTIFICATION (NO./TYPE/LOC.)	ELEMENT TYPE	ELEMENT LOC.	PART FAILURE DESCRIPTION	DISPOSITION
323778-1 VOTER PCB	COMPUTER	NAFC	COMPUTER HUNG UP IN HSMAT	REPLACED
ASR-7 BRAKE DRIVE ASSMBLY	ANTENNA	NAFC	SHORTED RELEASE SOLENOID	REPLACED
323746A LOG AMP PCB	RECEIVER	NAFC	GAIN 18 DB TOO HIGH	REPAIRED
1N755 ZENER VR-5	RECEIVER	NAFC	CAUSED LOG AMP FAILURE	THROWN AWAY
2N2439A Q23 AND Q24	RECEIVER	NAFC	PARTS OF SUM LOG AMP PCB	REPLACED
328579-1 AU-1 SER. 10043	COMPUTER	NAFC	CAUSED VOTING ERRORS	REPLACED
~~328579-1 AU-1 SER. 33013~~	~~COMPUTER~~	~~NAFC~~	~~CAUSED VOTING ERRORS~~	~~REPLACED~~
328579-1 AU-1 SER. 21019	COMPUTER	NAFC	CAUSED VOTING ERRORS	REPLACED
COOLING FAN	+5-V. P.S.	NAFC	DEFECTIVE- P.S. RAN HOT.	REPLACED

TABLE 18. DISTRIBUTION OF HARDWARE ELEMENT FAILURES IN NAFEC DABS SENSOR DURING THE PERIOD 5/30/78 TO 7/23/79

Element Type	No. Of Failures
Computers	22
Modems	6
+5-Volt Triplex Power Supplies	5
Transmitter	3
Receiver	3
Antenna	3
Tilines	2
176K Memories	2
Air Conditioners	2
Couplers	2
Processor	1
Interface PCB	1
Memmonserl (Memory Monitor PCB)	1
Comifserl (Communications PCB)	1
TOTAL	54

One of the two receiver failures involved the sum log amplifier. This failure was corrected by resoldering an electrical connection. The second receiver failure was corrected by adjusting the gain of the log amp PCB.

One of the two antenna failures involved problems with the drive motor related circuitry. The Tiline failures were due to defective exhaust fans.

Twelve of the 54 chargeable failures actually caused the system to go down. These were distributed as follows: transmitter, three; receiver, two; antenna, two; air conditioners, two; interface PCB's, one; processor, one; and memory monitor PCB, one. In table 16, these failures are indicated by the letter S inserted before them.

Of the unchargeable failures, 15 concerned TWT filament faults in the transmitter. The fault detection circuits work to detect improper filament voltages to the TWT tubes. The fault was indicated by a light and manually reset. Two consecutive surges without reset will power the transmitter down. Several instances of such powering down occurred during overnight periods when the system was unattended. The high incidence of these filament faults were due to improper alignment of the fault detection circuitry. This was realigned in May 1979, and the problem has essentially been corrected.

Eleven of the unchargeable failures involved the isolation and replacement of defective chips on the local memory PCB's, which are component parts of the DABS computers. These were located through the use of diagnostic routines during scheduled preventive maintenance time. However, the defective chips were spares and not actually used in the local memory circuitry.

Seventy-two part or component failures, and/or replacements, were recorded during this interval. These are documented in the ARAP printouts which are located at NAFEC. Thirty-two of these actions occurred on computer PCB's: 18 in the local memory PCB's, 12 in the AU PCB's, and 2 in the voter PCB's. Twelve of the 18 local memory PCB part actions were unchargeable as they comprised replacement of spare chips as described in the paragraph above. Therefore, there were 12 AU part actions, 6 local memory PCB part actions, and 2 voter PCB actions directly related to computer failures.

In addition to the 32 part failure/replacement actions associated with the computers, there were seven failed or defective cooling fans. These were associated with the Tilines, transmitter, modems, and +5-volt triplex power supplies.

RELIABILITY SUMMARIES. Using computerized mathematical models; element type, subsystem and system failure rates, and mean times between failures (MTBF's) were computed for the periods October 1, 1978, through April 30, 1979, and from May 1, 1979, to July 23, 1979. The April 30 date corresponds to the replacement of the original DABS antenna with the ATCRBS 5-foot antenna. These computed failure rates were then compared with the corresponding predicted values to further identify the location of problem areas.

The computations were made by entering into the computer: the total uptime, number of chargeable failures, and total repair times for each of the 22 element types shown in table 14. This information was obtained from the ARAP printouts. In addition to these 66 quantities, the maximum time for replacement of failed PCB's was also entered; the reason being that in the design and development of the DABS, it was felt that when removing a failed PCB from a Tiline, the Tiline should first be deenergized in order to prevent undesirable spikes or transients. Because of this, redundant elements connected to certain Tilines would be repaired immediately upon failure since these buses could be deenergized without causing system outage. In the case of buses, which must be continuously energized for the system to operate, failed redundant elements (or PCB's) would remain connected to such buses until a convenient time occurred in which to power down the bus and remove the failed PCB. Under worst-case conditions, this would be the next 30-day scheduled maintenance period (720 hours) as designated in the ER. In actual practice at NAFEC, preventive maintenance is performed daily, hence these failure rate determinations are made for both 720- and 24-hour maximum times to replacement of failed PCB's. These maximum replacement time factors are used in the determination of the failure rates of the computer and the communications subsystems since these make extensive use of redundant elements. Replacement time factors are not used in the determination of the interrogator and processor subsystem failure rate.

The failures per million hours and mean time to repair (MTTR) are then calculated for each of the 22 element types. This is done by the formulas:

$$\text{Failures per million hours} = \frac{\text{No. of Failures} \times 10^6}{\text{Total Uptime}}$$

$$\text{and MTTR} = \frac{\text{Total Repair Time}}{\text{No. of Failures}}$$

The system failure rate is the sum of the failure rates of the three subsystems. The MTBF was computed by the formula:

$$\text{MTBF} = 10^6/\text{system failures per million hours.}$$

Tables 19 and 20 show the summaries for the period October 1, 1978, to April 30, 1979, for 720- and 24-hour replacement times, respectively. Tables 21 and 22 show the corresponding summaries for the period May 1, 1979, to July 23, 1979, while tables 23 and 24 show corresponding cumulative summaries for the period October 1, 1978, to July 23, 1979.

Tables 25 and 26 show predicted element type, subsystem and system values for 720- and 24-hour replacement times, respectively. These were generated by using the predicted values for each element type that were used by the contractor in his reliability model to calculate the predicted MTBF as

TABLE 19. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL FROM 10/1/78 TO 4/30/79 (720 HOURS)

SITE= NAFEC

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 720 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL REPAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	4853.56	2	2.10	412.069	1.0
2. ANTENNA	4620.58	1	3.08	216.423	3.1
3. CHANNEL TRANSFER UNIT	4953.75	0	0.	0.	0.
4. TRANSMITTER	4753.03	2	4.70	420.784	2.3
5. RECEIVER	4852.58	1	4.83	206.076	4.8
6. PROCESSOR	4898.25	1	0.67	204.155	0.7
7. WWVB RECEIVER	4352.83	0	0.	0.	0.
8. TILINES	59422.34	3	1.83	50.486	0.6
9. COUPLERS	232556.85	2	0.25	8.600	0.1
10. INTERFACE PCB'S	24740.42	0	0.	0.	0.
11. +5-VOLT POWER SUPPLIES	178241.67	2	1.00	11.221	0.5
12. +/-12-VOLT POWER SUPPLIES	19815.00	0	0.	0.	0.
13. +/-12-VOLT POWER SUPPLY COMMON	4953.75	0	0.	0.	0.
14. DABS COMPUTERS	177996.78	9	5.12	50.563	0.6
15. 176K MEMORIES	29694.00	0	0.	0.	0.
16. MEMORY MONITOR SWITCHING ELEMENT	19799.75	0	0.	0.	0.
17. MEMORY MONITOR SERIAL ELEMENT	19799.75	1	0.50	50.506	0.5
18. COMM. I/F PCB SERIAL ELEMENT	74226.41	1	1.42	13.472	1.4
19. COMM. I/F PCB CHANNEL ELEMENT	148612.50	0	0.	0.	0.
20. MODEMS	79187.16	6	3.52	75.770	0.6
21. LINK SWITCHES	9897.92	0	0.	0.	0.
22. PRIMARY RADAR INTERFACE	4953.75	0	0.	0.	0.

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
A. INTERROGATOR AND PROCESSOR SUBSYSTEM	1459.506	2.2
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	54.720	0.6
2) ENSEMBLE GROUP	61.570	0.2
3) GLOBAL MEMORY GROUP	254.897	0.5
TOTAL COMPUTER SUBSYSTEM	371.182	0.5
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	61.903	0.5
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	107.737	0.6
TOTAL COMMUNICATIONS SUBSYSTEM	169.639	0.6

	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
3. SYSTEM SUMMARY - SINGLE CHANNEL	2000.333	1.8

SYSTEM MTBF 499 HOURS

TABLE 20. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL FROM 10/1/78 TO 4/30/79 (24 HOURS)

SITE= NAFEC

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 24 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL REPAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	4853.56	2	2.10	412.069	1.0
2. ANTENNA	4620.58	1	3.08	216.423	3.1
3. CHANNEL TRANSFER UNIT	4953.75	0	0.	0.	0.
4. TRANSMITTER	4753.03	2	4.70	420.784	2.3
5. RECEIVER	4852.58	1	4.83	206.076	4.8
6. PROCESSOR	4898.25	1	0.67	204.155	0.7
7. WWVB RECEIVER	4352.83	0	0.	0.	0.
8. TILINES	59422.34	3	1.83	50.486	0.6
9. COUPLERS	232556.85	2	0.25	8.600	0.1
10. INTERFACE PCB'S	24740.42	0	0.	0.	0.
11. +5-VOLT POWER SUPPLIES	178241.67	2	1.00	11.221	0.5
12. +/-12-VOLT POWER SUPPLIES	19815.00	0	0.	0.	0.
13. +/-12-VOLT POWER SUPPLY COMMON	4953.75	0	0.	0.	0.
14. DABS COMPUTERS	177996.78	9	5.12	50.563	0.6
15. 176K MEMORIES	29694.00	0	0.	0.	0.
16. MEMORY MONITOR SWITCHING ELEMENT	19799.75	0	0.	0.	0.
17. MEMORY MONITOR SERIAL ELEMENT	19799.75	1	0.50	50.506	0.5
18. COMM. I/F PCB SERIAL ELEMENT	74226.41	1	1.42	13.472	1.4
19. COMM. I/F PCB CHANNEL ELEMENT	148612.50	0	0.	0.	0.
20. MODEMS	79187.16	6	3.52	75.770	0.6
21. LINK SWITCHES	9897.92	0	0.	0.	0.
22. PRIMARY RADAR INTERFACE	4953.75	0	0.	0.	0.

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
A. INTERROGATOR AND PROCESSOR SUBSYSTEM	1459.506	2.2
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	50.637	0.6
2) ENSEMBLE GROUP	1.621	0.2
3) GLOBAL MEMORY GROUP	252.575	0.5
TOTAL COMPUTER SUBSYSTEM	304.833	0.6
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	50.890	0.6
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	65.708	0.8
TOTAL COMMUNICATIONS SUBSYSTEM	116.598	0.2

	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
3. SYSTEM SUMMARY - SINGLE CHANNEL	1880.937	1.8

SYSTEM MTBF 531 HOURS

TABLE 21. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL FROM 5/1/79 TO 7/23/79 (720 HOURS)

SITE= NAFEC

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 720 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL REPAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	1996.55	0	0.	0.	0.
2. ANTENNA	1948.88	0	0.	0.	0.
3. CHANNEL TRANSFER UNIT	1996.55	0	0.	0.	0.
4. TRANSMITTER	1988.05	0	0.	0.	0.
5. RECEIVER	1995.55	1	1.00	501.115	1.0
6. PROCESSOR	1996.55	0	0.	0.	0.
7. WWVB RECEIVER	1993.50	0	0.	0.	0.
8. TILINES	23958.60	0	0.	0.	0.
9. COUPLERS	93837.85	0	0.	0.	0.
10. INTERFACE PCB'S	9981.25	1	0.75	100.188	0.8
11. +5-VOLT POWER SUPPLIES	71875.05	2	0.75	27.826	0.4
12. +/-12-VOLT POWER SUPPLIES	7986.20	0	0.	0.	0.
13. +/-12-VOLT POWER SUPPLY COMMON	1996.55	0	0.	0.	0.
14. DABS COMPUTERS	71727.85	10	5.20	139.416	0.5
15. 176K MEMORIES	11978.18	2	1.12	166.970	0.6
16. MEMORY MONITOR SWITCHING ELEMENT	7986.20	0	0.	0.	0.
17. MEMORY MONITOR SERIAL ELEMENT	7986.20	0	0.	0.	0.
18. COMM. I/F PCB SERIAL ELEMENT	29948.25	0	0.	0.	0.
19. COMM. I/F PCB CHANNEL ELEMENT	59896.50	0	0.	0.	0.
20. MODEMS	31944.80	0	0.	0.	0.
21. LINK SWITCHES	3993.10	0	0.	0.	0.
22. PRIMARY RADAR INTERFACE	1996.55	0	0.	0.	0.

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

A. INTERROGATOR AND PROCESSOR SUBSYSTEM	501.115	1.0
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	123.499	0.7
2) ENSEMBLE GROUP	0.001	0.3
3) GLOBAL MEMORY GROUP	497.848	0.7
TOTAL COMPUTER SUBSYSTEM	621.347	0.7
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	64.535	0.3
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	0.002	0.2
TOTAL COMMUNICATIONS SUBSYSTEM	64.537	0.3

3. SYSTEM SUMMARY - SINGLE CHANNEL 1186.999 0.8

SYSTEM MTBF 842 HOURS

TABLE 22. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL FROM 5/1/79 TO 7/23/79 (24 HOURS)

SITE= NAFEC

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 24 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL REPAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	1996.55	0	0.	0.	0.
2. ANTENNA	1948.88	0	0.	0.	0.
3. CHANNEL TRANSFER UNIT	1996.55	0	0.	0.	0.
4. TRANSMITTER	1988.05	0	0.	0.	0.
5. RECEIVER	1995.55	1	1.00	501.115	1.0
6. PROCESSOR	1996.55	0	0.	0.	0.
7. WWVB RECEIVER	1993.50	0	0.	0.	0.
8. TILINES	23958.60	0	0.	0.	0.
9. COUPLERS	93837.85	0	0.	0.	0.
10. INTERFACE PCB'S	9981.25	1	0.75	100.188	0.8
11. +5-VOLT POWER SUPPLIES	71875.05	2	0.75	27.826	0.4
12. +/-12-VOLT POWER SUPPLIES	7986.20	0	0.	0.	0.
13. +/-12-VOLT POWER SUPPLY COMMON	1996.55	0	0.	0.	0.
14. DABS COMPUTERS	71727.85	10	5.20	139.416	0.5
15. 176K MEMORIES	11978.18	2	1.12	166.970	0.6
16. MEMORY MONITOR SWITCHING ELEMENT	7986.20	0	0.	0.	0.
17. MEMORY MONITOR SERIAL ELEMENT	7986.20	0	0.	0.	0.
18. COMM. I/F PCB SERIAL ELEMENT	29948.25	0	0.	0.	0.
19. COMM. I/F PCB CHANNEL ELEMENT	59896.50	0	0.	0.	0.
20. MODEMS	31944.80	0	0.	0.	0.
21. LINK SWITCHES	3993.10	0	0.	0.	0.
22. PRIMARY RADAR INTERFACE	1996.55	0	0.	0.	0.

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
A. INTERROGATOR AND PROCESSOR SUBSYSTEM	501.115	1.0
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	101.116	0.7
2) ENSEMBLE GROUP	0.000	0.3
3) GLOBAL MEMORY GROUP	404.738	0.7
TOTAL COMPUTER SUBSYSTEM	505.854	0.7
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	2.773	0.3
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	0.002	0.2
TOTAL COMMUNICATIONS SUBSYSTEM	2.775	0.3

3. SYSTEM SUMMARY - SINGLE CHANNEL 1009.743 0.9

SYSTEM MTBF 990 HOURS

TABLE 23. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL FROM 10/1/78 TO 7/23/79 (720 HOURS)

SITE= NAFEC

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 720 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL RE-PAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	6850.11	2	2.10	291.966	1.0
2. ANTENNA	6569.46	1	3.08	152.220	3.1
3. CHANNEL TRANSFER UNIT	6950.30	0	0.	0.	0.
4. TRANSMITTER	6741.08	2	4.70	296.688	2.3
5. RECEIVER	6848.13	2	5.83	292.051	2.9
6. PROCESSOR	6894.80	1	0.67	145.037	0.7
7. WWVB RECEIVER	6346.33	0	0.	0.	0.
8. TILINES	83380.94	3	1.83	35.979	0.6
9. COUPLERS	326394.70	2	0.25	6.128	0.1
10. INTERFACE PCB'S	34721.67	1	0.75	28.800	0.8
11. +5-VOLT POWER SUPPLIES	250116.72	4	1.75	15.993	0.4
12. +/-12-VOLT POWER SUPPLIES	27801.20	0	0.	0.	0.
13. +/-12-VOLT POWER SUPPLY COMMON	6950.30	0	0.	0.	0.
14. DABS COMPUTERS	249724.63	19	10.32	76.084	0.5
15. 176K MEMORIES	41672.18	2	1.12	47.994	0.6
16. MEMORY MONITOR SWITCHING ELEMENT	27785.95	0	0.	0.	0.
17. MEMORY MONITOR SERIAL ELEMENT	27785.95	1	0.50	35.989	0.5
18. COMM. I/F PCB SERIAL ELEMENT	104174.66	1	1.42	9.599	1.4
19. COMM. I/F PCB CHANNEL ELEMENT	208509.00	0	0.	0.	0.
20. MODEMS	111131.96	6	3.52	53.990	0.6
21. LINK SWITCHES	13891.02	0	0.	0.	0.
22. PRIMARY RADAR INTERFACE	6950.30	0	0.	0.	0.

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
A. INTERROGATOR AND PROCESSOR SUBSYSTEM	1172.961	2.1
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	72.708	0.6
2) ENSEMBLE GROUP	53.032	0.2
3) GLOBAL MEMORY GROUP	305.680	0.6
TOTAL COMPUTER SUBSYSTEM	431.420	0.6
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	58.627	0.5
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	68.170	0.6
TOTAL COMMUNICATIONS SUBSYSTEM	126.297	0.6

3. SYSTEM SUMMARY - SINGLE CHANNEL 1736.179 1.6

SYSTEM MTBF 575 HOURS

TABLE 24. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL FROM 10/1/78 TO 7/23/79 (24 HOURS)

SITE= NAFEC

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 24 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL REPAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	6850.11	2	2.10	291.966	1.0
2. ANTENNA	6569.46	1	3.08	152.220	3.1
3. CHANNEL TRANSFER UNIT	6950.30	0	0.	0.	0.
4. TRANSMITTER	6741.08	2	4.70	296.688	2.3
5. RECEIVER	6848.13	2	5.83	292.051	2.9
6. PROCESSOR	6894.80	1	0.67	145.037	0.7
7. WWVB RECEIVER	6346.33	0	0.	0.	0.
8. TILINES	83380.94	3	1.83	35.979	0.6
9. COUPLERS	326394.70	2	0.25	6.128	0.1
10. INTERFACE PCB'S	34721.67	1	0.75	28.800	0.8
11. +5-VOLT POWER SUPPLIES	250116.72	4	1.75	15.993	0.4
12. +/-12-VOLT POWER SUPPLIES	27801.20	0	0.	0.	0.
13. +/-12-VOLT POWER SUPPLY COMMON	6950.30	0	0.	0.	0.
14. DABS COMPUTERS	249724.63	19	10.32	76.084	0.5
15. 176K MEMORIES	41672.18	2	1.12	47.994	0.6
16. MEMORY MONITOR SWITCHING ELEMENT	27785.95	0	0.	0.	0.
17. MEMORY MONITOR SERIAL ELEMENT	27785.95	1	0.50	35.989	0.5
18. COMM. I/F PCB SERIAL ELEMENT	104174.66	1	1.42	9.599	1.4
19. COMM. I/F PCB CHANNEL ELEMENT	208509.00	0	0.	0.	0.
20. MODEMS	111131.96	6	3.52	53.990	0.6
21. LINK SWITCHES	13891.02	0	0.	0.	0.
22. PRIMARY RADAR INTERFACE	6950.30	0	0.	0.	0.

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
A. INTERROGATOR AND PROCESSOR SUBSYSTEM	1172.961	2.1
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	65.072	0.7
2) ENSEMBLE GROUP	0.864	0.2
3) GLOBAL MEMORY GROUP	295.504	0.6
TOTAL COMPUTER SUBSYSTEM	361.440	0.6
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	36.829	0.6
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	46.468	0.8
TOTAL COMMUNICATIONS SUBSYSTEM	83.297	0.7

3. SYSTEM SUMMARY - SINGLE CHANNEL 1622.698 1.7

SYSTEM MTBF 616 HOURS

TABLE 25. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL (720 HOURS)

SITE= NAFEC FROM= PREDICTED TO= VALUES

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 720 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL RE-PAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	28286.00	2	4.00	70.706	2.0
2. ANTENNA	86207.00	1	2.00	11.600	2.0
3. CHANNEL TRANSFER UNIT	2000.00	0	0.	0.	0.
4. TRANSMITTER	4605.00	1	2.00	217.155	2.0
5. RECEIVER	4278.00	1	2.00	233.754	2.0
6. PROCESSOR	7673.00	1	2.00	130.327	2.0
7. WWVB RECEIVER	2000.00	0	0.	0.	0.
8. TILINES	500000.00	1	2.00	2.000	2.0
9. COUPLERS	116279.00	1	2.00	8.600	2.0
10. INTERFACE PCB'S	44964.00	1	2.00	22.240	2.0
11. +5-VOLT POWER SUPPLIES	35920.00	10	20.00	278.396	2.0
12. +/-12-VOLT POWER SUPPLIES	18410.00	5	10.00	271.592	2.0
13. +/-12-VOLT POWER SUPPLY COMMON	2000.00	0	0.	0.	0.
14. DABS COMPUTERS	23330.00	5	10.00	214.316	2.0
15. 176K MEMORIES	7974.00	1	2.00	125.408	2.0
16. MEMORY MONITOR SWITCHING ELEMENT	508906.00	2	4.00	3.930	2.0
17. MEMORY MONITOR SERIAL ELEMENT	925926.00	1	2.00	1.080	2.0
18. COMM. I/F PCB SERIAL ELEMENT	89928.00	1	2.00	11.120	2.0
19. COMM. I/F PCB CHANNEL ELEMENT	179856.00	1	2.00	5.560	2.0
20. MODEMS	45000.00	3	6.00	66.667	2.0
21. LINK SWITCHES	317460.00	1	2.00	3.150	2.0
22. PRIMARY RADAR INTERFACE	297619.00	1	2.00	3.360	2.0

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

A. INTERROGATOR AND PROCESSOR SUBSYSTEM	592.856	2.0
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	76.515	1.3
2) ENSEMBLE GROUP	218.602	1.0
3) GLOBAL MEMORY GROUP	159.691	1.6
TOTAL COMPUTER SUBSYSTEM	454.809	1.3
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	143.324	1.0
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	100.976	1.3
TOTAL COMMUNICATIONS SUBSYSTEM	244.299	1.1

3. SYSTEM SUMMARY - SINGLE CHANNEL 1291.965 1.6

SYSTEM MTBF 774 HOURS

TABLE 26. DABS RELIABILITY SUMMARIES — SINGLE CHANNEL (24 HOURS)

SITE= NAFEC FROM= PREDICTED TO= VALUES

MAXIMUM TIME TO REPLACEMENT OF FAILED PCB'S= 24 HOURS

1. ELEMENT TYPE SUMMARY

	TOTAL UPTIME (ELEMENT-HOURS)	NO. OF FAILURES	TOTAL REPAIR TIME (ELEMENT-HOURS)	FAILURES PER MILLION HOURS	MEAN TIME TO REPAIR (HOURS)
1. AIR CONDITIONERS	28286.00	2	4.00	70.706	2.0
2. ANTENNA	86207.00	1	2.00	11.600	2.0
3. CHANNEL TRANSFER UNIT	2000.00	0	0.	0.	0.
4. TRANSMITTER	4605.00	1	2.00	217.155	2.0
5. RECEIVER	4278.00	1	2.00	233.754	2.0
6. PROCESSOR	7673.00	1	2.00	130.327	2.0
7. WWVB RECEIVER	2000.00	0	0.	0.	0.
8. TILINES	500000.00	1	2.00	2.000	2.0
9. COUPLERS	116279.00	1	2.00	8.600	2.0
10. INTERFACE PCB'S	44964.00	1	2.00	22.240	2.0
11. +5-VOLT POWER SUPPLIES	35920.00	10	20.00	278.396	2.0
12. +/-12-VOLT POWER SUPPLIES	18410.00	5	10.00	271.592	2.0
13. +/-12-VOLT POWER SUPPLY COMMON	2000.00	0	0.	0.	0.
14. DABS COMPUTERS	23330.00	5	10.00	214.316	2.0
15. 176K MEMORIES	7974.00	1	2.00	125.408	2.0
16. MEMORY MONITOR SWITCHING ELEMENT	508906.00	2	4.00	3.930	2.0
17. MEMORY MONITOR SERIAL ELEMENT	925926.00	1	2.00	1.080	2.0
18. COMM. I/F PCB SERIAL ELEMENT	89928.00	1	2.00	11.120	2.0
19. COMM. I/F PCB CHANNEL ELEMENT	179856.00	1	2.00	5.560	2.0
20. MODEMS	45000.00	3	6.00	66.667	2.0
21. LINK SWITCHES	317460.00	1	2.00	3.150	2.0
22. PRIMARY RADAR INTERFACE	297619.00	1	2.00	3.360	2.0

2. SUBSYSTEM SUMMARY - SINGLE CHANNEL

A. INTERROGATOR AND PROCESSOR SUBSYSTEM	592.856	2.0
B. COMPUTER SUBSYSTEM		
1) ATCRBS GROUP	27.381	1.9
2) ENSEMBLE GROUP	1.434	1.0
3) GLOBAL MEMORY GROUP	100.467	2.0
TOTAL COMPUTER SUBSYSTEM	129.282	1.9
C. COMMUNICATIONS SUBSYSTEM		
1) COMMUNICATIONS CONSOLE (INCLUDING COMPUTERS)	9.504	1.2
2) COMMUNICATIONS INTERFACE CONSOLE (INCLUDING MODEMS)	38.422	1.9
TOTAL COMMUNICATIONS SUBSYSTEM	47.926	1.7

3. SYSTEM SUMMARY - SINGLE CHANNEL	770.065	2.0

SYSTEM MTBF 1298 HOURS

required by the ER. The total uptimes, number of failures, and total repair times for each element type are purely hypothetical values used to generate the predicted element type failures per million hours and MTTR's.

Table 27 compares the observed cumulative failure rates against the corresponding predicted values. For the 720-hour replacement criterion, the observed system failure rate was 1736.179 failures per million hours while the predicted failure rate was 1291.965 failures per million hours. The corresponding observed versus predicted system failure rates for the 24-hour replacement criterion were 1622.698 versus 770.065 failures per million hours. These correspond to observed system MTBF's of 575 hours for the 720-hour criterion and 616 hours for the 24-hour replacement criterion. These are below the corresponding predicted values of 774 and 1298 hours, respectively, or the 1000-hour value specified in the ER.

The high observed system failure rates for both replacement criteria are principally due to the interrogator and processor subsystem. These had observed failure rates of 1177.794 failures per million hours as compared with a predicted value of 592.856 failures per million hours. The elements in the interrogator and processor subsystem which contribute to this high failure rate are: the antenna, the transmitter, the receiver, the processor, and the air conditioner. Three of these five elements had two or more failures during the cumulative reporting period and, as seen in table 27, had observed failure rates which substantially exceeded the predicted values. The transmitter, receiver, antenna, and processor are series-string elements (no redundancy), hence, their failure rates are additive. In the case of the air conditioners, the reliability model called for two air conditioners operating simultaneously for each site. One air conditioner would be redundant, or a backup. Using a redundancy formula, this would make the predicted failure rate for the one out of two redundant air conditioner combination 0.02 failures per million hours rather than the 70.706 failures per million hour value for a single air conditioner. The predicted values shown in tables 25 and 26 were generated using the redundant air conditioners shown in the reliability mode.

NAFEC uses a single built-in air conditioner whose actual failure rate turned out to be 291.966 failures per million hours. The observed summaries shown in tables 19 to 24 were generated using this single air conditioner rather than the redundant combination used in generating the predicted values of tables 25 and 26. If a single air conditioner was duplicated in a redundant combination, the cumulative MTBF for the 720-hour replacement rate would have been 692 rather than 576 hours. For the 24-hour replacement rate the cumulative MTBF would have been 751 rather than 616 hours.

The actual air conditioners delivered to the Elwood and Clementon sites are single units rather than the redundant units called for in the reliability model. Use of such single units would increase the overall system failure rate, thereby reducing the system MTBF.

TABLE 27. COMPARISON OF OBSERVED VERSUS PREDICTED FAILURE RATE AND MTBF's

1. Element Type Failure Rates		Observed Value	Predicted Value
1.	Air Conditioners	291.966 *	70.706
2.	Antenna	152.220 *	11.6
3.	Channel Transfer Unit	-------	-------
4.	Transmitter	296.688 *	217.155
5.	Receiver	292.051 *	233.754
6.	Processor	145.037 *	130.327
7.	WWVB Receiver	-------	-------
8.	Tilines	35.979 *	2.000
9.	Couplers	6.128	8.600
10.	Interface PCB	28.800 *	22.24
11.	+ 5-Volt Triplex Power Supplies	15.993	278.396
12.	±12-Volt Power Supplies	0	271.592
13.	12-Volt Common	-------	-------
14.	DABS Computers	76.084	214.316
15.	176k Memories	47.994	125.408
16.	Memory Monitor Switch Element	0	3.93
17.	Memory Monitor Serial Element	35.989 *	1.08
18.	Comm. Interface - Serial	9.599	11.12
19.	Comm. Interface - Channel	0	5.56
20.	Modems	53.990	66.667
21.	Link Switches	0	3.15
22.	Primary Radar Interface	0	3.36

2. Subsystem Failure Rates			
A.	Interrogator and Processor	1177.961 *	592.856
B.	Computer (720-Hour Repl.)	431.420 *	454.809
	(24-Hour Repl.)	361.440 *	129.282
C.	Communications (720-Hour Repl.)	126.797	244.299
	(24-Hour Repl.)	83.297 *	47.926

3. System Failure Rates		
(720-Hour Replacement)	1736.179 *	1291.965
(24-Hour Replacement)	1622.698 *	770.065

4. System MTBF		
(720-Hour Replacement)	575	774
(24-Hour Replacement)	616	1298
(SPECIFIED — ER)	1000	

* Observed Values Exceed Predicted Values

If the antenna and air conditioners are excluded, then the system MTBF is 770 hours for the 720-hour maintenance criterion and 848 hours for the 24-hour maintenance criterion. The corresponding predicted values are 781 and 1318 hours, respectively.

SUMMARY OF RESULTS

SURVEILLANCE SIMULATION.

1. The probability of detection (P_d) of either Air Traffic Control Radar Beacon System (ATCRBS) or Discrete Address Beacon System (DABS) targets was greater than 98 percent. A reduction in round reliability (R/R) from a nominal 0.93 to a worst-case of 0.70 resulted in an 8 percent loss of ATCRBS detection. A worst-case fruit rate of 44,000 per second ATCRBS total fruit, and 200 DABS main beam fruit caused a 5 percent loss of ATCRBS target detection. DABS target detection loss was less than 2 percent for both low R/R and high fruit environments. The minimum useable signal level (MUSL) was determined to be -78 decibels above 1 milliwatt (dBm) for both DABS and ATCRBS targets.

2. The DABS identification (ID) reliability was consistently 100 percent. The mode A-code reliability for ATCRBS targets was generally 100 percent and always greater than 98 percent. The DABS ID and ATCRBS mode A-code reliability was nearly 100 percent for signal levels down to -78 dBm. These results were obtained for a high R/R of 0.93 and a low value of 0.70. The ATCRBS fruit rates were 0, 50, and 200 per second. The 100 percent reliability for DABS was achieved because a valid DABS reply contained the expected ID, while an invalid reply was rejected and required another interrogation. The ATCRBS code reliability was high because low confidence and/or incorrect codes were corrected before dissemination by the surveillance tracker.

3. Altitude reliability for DABS roll-call targets was 100 percent and far superior to that achieved for ATCRBS targets. ATCRBS altitude reliability was especially sensitive to reductions in R/R, increases in fruit rate, and proximity of conflicting aircraft. Reduction in R/R from 0.93 to 0.70 lowered the ATCRBS altitude reliability from 98 to 89 percent. In addition, high fruit rates (44,000 per second) or conflicting targets each reduced ATCRBS altitude reliability from 98 to 88 percent.

4. The average number of DABS interrogations per scan for each target was 1.2. This number was independent of fruit rate and was measured using an R/R of 0.93.

5. The number of DABS interrogations for targets transitioning through the zenith cone was extremely high. Between 100 and 180 interrogations, depending on aircraft altitude, were transmitted during the six scans after the target entered the zenith cone and prior to its track drop. These results were obtained with no DABS reinterrogations within a single DABS period.

6. No DABS or discrete ATCRBS track swaps were observed during simulation testing.

7. The capacity tests of 400 aircraft in 360° and Los Angeles (L.A.) Basin consisting of 282 targets in 90° capacity scenarios yielded a P_d of approximately 98 percent. This is comparable to the results achieved with the basic scenario.

8. ATCRBS and DABS processing as specified for short-term capacity in the ER was not achieved. A portion of the problem could be attributable to the reduction in antenna beam width from that for which the sensor was originally designed. Other system improvements are also being evaluated in light of changing requirements. Investigation into this reduction in performance has been initiated.

9. The average number of ATCRBS replies per report was 3.8 for a 0.93 R/R and a 2.4° beam width.

10. Track acquisition of proximate DABS targets was delayed because of All-Call garbling. A solution for this problem has been identified.

11. ATCRBS targets entering the zenith cone encountered difficulty in maintaining correct track updating. ATCRBS tracks in the zenith cone would often correlate to false radar reports close to the sensor.

FAILURE/RECOVERY.

12. The DABS sensor recovered from all single computers and most ensemble failures within one or two scans after the occurrence of the failure. Modem and global memory failures were successfully handled by the sensor. Several changes to the original baseline-released software were required to correct errors in the performance monitoring and failure/recovery coding. Once these changes were incorporated, the above results were obtained with problems only occurring when the failure/recovery, performance monitor, and primary standby computers had all failed. This is considered a low probability event. These problems are currently under investigation.

DABS SENSOR/ARTS III COMPARISON TESTS.

13. The target performance of the ATCRBS mode of DABS was equal to or greater than that achieved with the ARTS III for the test aircraft and targets of opportunity. The P_d for DABS and ARTS III was 96.4 and 96.2 percent, respectively. The mode A-code reliability was 99.3 and 96.5 percent, respectively. The altitude reliability was 95.7 percent for DABS and 94.5 percent for ARTS. When the DABS engineering model sensor transmitter power and effective beam width are increased improved DABS performance is anticipated.

14. The average number of ATCRBS replies per report for the DABS sensor was 3.6. This number was lower than the expected average of 4.0, and is attributed to the effective beam width of 2.4° used during baseline testing.

COMMUNICATIONS (Comm) A/B.

15. All Comm A/B messages were delivered during the basic 42-aircraft scenario testing. In 10 percent of the cases for which three transactions per aircraft were attempted in a single scan, a second scan was required to complete the transaction. The Comm A/B requirements under a short-term load (48 targets in 4°) could not be tested because of surveillance problems as noted in number 8 of the SUMMARY OF RESULTS section. In the 400 aircraft in 360° scenario, all Comm A/B messages were delivered. The Comm A/B message delivery and timing were properly handled during the L.A. Basin capacity test. Extended length message (ELM) testing was not conducted since the Aircraft Reply and Interference Environmental Simulator (ARIES) does not have ELM capability, and ELM-equipped transponders were not available.

SENSOR-TO-ATC INTERFACE.

16. The use of unconditioned telephone lines for transmission of data between a DABS sensor and ATC facilities was satisfactory. The major problem encountered was due to deficiencies with the version of the Common International Civil Aviation Organization (ICAO) Data Interchange Network (CIDIN) protocol using the DABS engineering model.

RELIABILITY.

17. The mean time between failures (MTBF) of the system (not including the antenna and the air conditioner) is estimated to be 770 hours, assuming that preventive maintenance is performed only once per month (720 hours). This estimate is based on 9 months of accumulated failure data. The predicted MBTF was 781 hours.

18. The MTBF estimates obtained for the major DABS elements are as follows:

Transmitter	3,300 hours
Receiver	3,400 hours
Processor	6,900 hours
Computers	13,000 hours
Modems	18,500 hours
Memories (180,224)	21,000 hours

19. Three chargeable failures occurred in the Tilines. Each of these involved the Rotron cooling or exhaust fan. In addition to the three failed fans in the Tilines, four additional cooling fans failed in the system over this period of observation.

CONCLUSION

It was concluded that the Discrete Address Beacon System (DABS) engineering sensor in a terminal configuration, as implemented by Texas Instruments (TI), Incorporated and tested to date, complied with or exceeded the requirements specified in the DABS Engineering Requirement (FAA-ER-240-26) except for a few areas, which are discussed in the SUMMARY OF RESULTS section. The results of the DABS system test and evaluation showed improved report reliability, substantially greater azimuth accuracy as compared to the current Air Traffic Control Radar Beacon System (ATCRBS), and a highly reliable air-ground communications link.

RECOMMENDATIONS

1. The short-term capacity values specified in the engineering requirement (ER) should be reevaluated prior to undertaking any capacity improvement modifications of the engineering model.

2. The Discrete Address Beacon System (DABS) channel management software, as implemented in the DABS sensor, should be modified to permit rescheduling of roll-calls within a DABS period, and to better support the Automatic Traffic Advisory Resolution Service (ATARS). It is expected that a more efficient implementation of the channel management function would also increase the sensor capacity.

3. DABS targets should be dropped upon entering the zenith cone for a non-netted system so as to suppress unnecessary interrogations.

4. A complete description of the failure/recovery requirements should be included in the DABS production specification. This document should consider a distributive processing architecture in support of failure recovery, which provides for full flexibility of computers and ensembles.

5. The ER for the production DABS should specify the use of unconditioned type 3002 telephone lines at 4800 bits per second (bps) for all interfacility DABS links.

6. An investigation should be conducted to ensure that proposed modifications to the Common International Civil Aviation Organization (ICAO) Data Interchange Network (CIDIN) protocol will resolve the deficiencies noted in the version implemented in the DABS engineering model.

7. DABS should have redundant elements for the transmitter, receiver, and processor to meet the 20,000-hour mean time between failures (MTBF) requirement.

8. A maximum azimuth bias which was not specified in the original ER should be included in the Technical Data Package (TDP) DABS specifications.

9. Stochastic acquisition, as defined in the draft of the DABS National Standard dated October 1979, should be used in acquiring proximate DABS aircraft in the All-Call mode.

10. Air Traffic Control Radar Beacon System (ATCRBS) targets should be dropped after six consecutive misses when in the zenith cone of a single sensor.

11. The current requirements for dissemination of ATCRBS altitude to air traffic control (ATC) facilities should be modified. An alternate method, where targets with mode C-codes having bad confidence are converted to altitude and given a reasonableness test before dissemination, should be considered.

APPENDIX A

BASIC 42-AIRCRAFT SCENARIO

SCENARIO DESCRIPTION.

The basic 42-aircraft configuration was designed to thoroughly exercise the surveillance functions of the Discrete Address Beacon System (DABS). Four of the targets were used only for synchronization of the data reduction and analysis programs. The purposes for the remaining targets are as defined in table A-1.

PROBABILITY OF DETECTION (P_d).

The P_d scenario was comprised of 40 targets flying orbits and 4 stationary targets that were used by the data reduction and analysis programs for synchronization. Twenty of the 40 targets started at an azimuth of 90°, were evenly spaced in range from 7 to 100 nautical miles (nmi), and flew a counter-clockwise orbit. The next group of 20 targets started at an azimuth of 270°, were evenly spaced in range from 105 to 200 nmi, and flew a clockwise orbit. The target starts were staggered in groups of 10. All orbiting targets were at a flight level of 30,000 feet, the stationary targets at a flight level of 15,000 feet.

CAPACITY.

The scenarios designed to evaluate the capacity capability of the DABS consisted of three different configurations: a wedge of targets, 282 targets within 60 nmi and 90°, and 400 targets within 360°. The wedge consisted of 50 targets of which 2 were fixed targets used by the data reduction and analysis program for synchronization. The remaining 48 targets were distributed over four contiguous 1° sectors, with each sector having no more than 12 targets.

The 48 targets had starts staggered every 20 scans so that no pair within 5 nmi started together. All of the targets were visible by scan 80. They were at 12,000 feet with azimuths between 90° and 94°. The range extended from 5.37 to 53 nmi with approximately 1-nmi separation between successive aircraft, and a 2-nmi separation between the furthest pair.

The 282 targets within 60 nmi and 90° scenario was commonly referred to as the 1990 Los Angeles Basin model. This scenario consisted of a total of 360 targets, of which 190 were DABS and 170 were ATCRBS. Most of the targets were contained within 60 nmi at a variety of flight levels and azimuth positions within the 90° wedge.

TABLE A-1. SCENARIO DESCRIPTION

Scenario Target Identifier	Description Of Scenario Target Maneuvers
A-B-C-D	1. These targets comprise a set of four aircraft whose altitude separation is 600 feet, and which engage in multiple conflicts. a. Conflict 1 involves three aircraft. One aircraft flies south along north mark (NM), while the other two fly across the third with angles of intersection of 55° and 60°. The Air Traffic Control Radar Beacon System (ATCRBS) mode A-codes are unique discrete in the all-ATCRBS scenario. The southbound aircraft and one of the other aircraft have DABS identification in the mixed scenario. Objectives: - Test the DABS' ability to track a NM radial trajectory (area of azimuth discontinuity). - Test the tracker's ability to resolve and identify aircraft during a NM conflict. b. The southbound aircraft flies into and out of the zenith cone. c. Conflict 2 involves two aircraft, one flying southeast, the other southwest, whose trajectories simultaneously intersect each other and a third southbound aircraft. The third aircraft continues southward while the other two angle outbound to the east and the west. The three aircraft regroup around the south mark, where they are intersected by a fourth aircraft flying in a straight line pattern. The objective is to assess the sensor's ability to resolve a four-target conflict.
E-N-B	2. These are ATCRBS discrete and nondiscrete and DABS targets traversing the zenith cone. There is one target turning in the cone of silence (COS). The objective is to observe the sensor tracking response to COS targets. In the 200-nmi scenario, there is also a unique discrete ATCRBS target descending while in the COS.

TABLE A-1. (Continued)

Scenario Target Identifier	Description Of Scenario Target Maneuvers
701x,702x,703x	3. An ATCRBS target flies the region 1-2 tracking zone boundary. The region forms the transition from a first-order to second-order ρ, θ tracker. The objective in generating this flightpath is to assess the sensor tracking response in this region. This target is an element of a set of three aircraft coming in conflict over NM. All targets are identically nondiscrete, but fly at different flight levels with minimum separations of 600 feet.
801x,802x	4. A set of targets flies multiple intersecting paths in tracking region 1 (outermost). These targets are both DABS targets in the mixed scenario and discrete unique mode A-codes in ATCRBS scenario. The altitude separation is 700 feet. The intersecting angle is approximately 30°. In the DABS scenario, the objective is to assess the sensor's ability to transact ground-to-air-to-ground communications in conflict situations.
601x602x	5. Two aircraft trajectories intersect at approximately 10°. The trajectories are identical in both the ATCRBS and mixed scenarios. One of the aircraft changes its code from nondiscrete to discrete and complementary to the other aircraft code just prior to the conflict. After the conflict, both aircraft change codes to radio failure 7600 and emergency 7700, respectively. The altitude separation is 600 feet during the full trajectory. Objectives: a. to evaluate shallow-angle crossing path tracking, b. to evaluate the sensor's ability to decouple complementary mode A-codes during a conflict, and c. to determine system response to emergency codes.
U-W	6. This is a pair of intersecting trajectories which cross at 64°. Both aircraft have nondiscrete, identical mode A-codes in the mixed and ATCRBS scenarios. The altitude separation is 600 feet.

TABLE A-1. (Continued)

Scenario Target Identifier	Description Of Scenario Target Maneuvers
803x	7. A target flies a closed, circular path into and out of the zenith cone. The purpose for this trajectory is to assess the ground-to-air-to-ground data link in the zenith cone proximity.
501x,502x,503x	8. A set of three aircraft flies in the same vertical plane separated from each other by 0.7 nmi and 1,000 feet. All have ATCRBS discrete codes in the ATCRBS scenario and the aircraft flying the middle flight level is a DABS target in the mixed scenario. The objective is to evaluate the sensor's ability to track through a potential continuous garble situation.
401x,402x	9. A set of two aircraft flies parabolic paths whose point of closest approach (at the vertex of each trajectory) is approximately 750 feet. Both targets are nondiscrete but unique with respect to each other. The flight levels are identical. The purpose for this conflict is an attempt to cause a track swap response in the sensor.
301x,302x	10. A pair of aircraft flies in overtake pattern. The altitude separation is 600 feet, and mode A-codes are unique, discrete, and complementary. Both the ATCRBS and mixed scenario have identical aircraft specifications. The relative velocity is 50 knots. In the mixed scenario, one aircraft is DABS the other ATCRBS.
101x	11. An aircraft flies west to east while decelerating from 650 knots to 250 knots and then accelerating back to 650 knots. The target is an ATCRBS with a discrete mode A-code. The purpose for this flight path is to determine the sensor's ability to track an accelerating aircraft.
201x,202x	12. A pair of aircraft widely separated execute a 180° turn in the vicinity of NM. One aircraft turn is executed in tracking region 1 (far out) and the other is in the near tracking region (region 3). NM proximity was chosen to complicate the prediction process. The far-out aircraft is a unique discrete ATCRBS mode A-code, while the close-in

TABLE A-1. (Continued)

Scenario Target Identifier		Description Of Scenario Target Maneuvers
		aircraft is nondiscrete. The close-in aircraft simulates landings. Both aircraft specifications are identical in ATCRBS and mixed baseline scenarios.
O-P-Q	13.	Target O is a flyover, target Q is a real target, and target P is a false target which is a reflection of Q from the hangar at the National Aviation Facilities Experimental Center (NAFEC). The purpose is to assess the sensor's ability to label false and/or real targets when reflector geometry is included in the appropriate site-adapted data bases. The target (and reflection) identification is ATCRBS, unique, and discrete in both the baseline ATCRBS and mixed scenarios.
F-G-H	14.	A set of three aircraft is involved, two of which are flying parallel to each other at the same flight level while the third intersects the path of the other two twice; first at a 50° angle of intersection and then at a 15° angle of intersection. The altitude of the intruding aircraft is 600 feet above the other aircraft. All targets are identified by the same nondiscrete mode A-code. In addition to testing conflict resolution capability, these tracks are designed to create linked track sets to determine if they are handled properly.
K	15.	An aircraft executes a closed-path trajectory in the region 1 tracking area. Its trajectory does not intersect that of any other aircraft. This aircraft is a unique discrete ATCRBS target in the baseline ATCRBS scenario, and a DABS target in the mixed scenario. Its purpose is to assess sensor ability to follow turns in nonconflict situations.
I-J	16.	A pair of aircraft is involved whose ground trajectories approach head-on. The altitude separation is 600 feet. These targets are unique discrete in the ATCRBS baseline scenario. In the mixed scenario, one target maintains its ATCRBS identification, while the other becomes a DABS target. The purpose for the targets is to attempt to invoke conflict alert, since altitude garbling during the path approach is likely in the ATCRBS baseline case.

TABLE A-1. (Continued)

Scenario Target Identifier		Description Of Scenario Target Maneuvers
Y	17.	One aircraft flies a trajectory which traverses the coverage region while keeping within the region 1 tracking area.
Z	18.	A target which generates a long track history executes a turn at 65°, flies out of coverage, turns while outside of coverage, and reenters the coverage region.
Fix 1 Fix 2 Fix 3 Fix 4	19.	Four targets flying outbound radials of 15°, 105°, 195°, 285°, at 200 knots with codes of 7654, 6754, 7645, 7465, respectively, become stationary after 32 scans. These targets are used to synchronize the Aircraft Reply and Interference Environmental Simulator (ARIES) and DABS data extraction tapes.

The 400 targets within 60 nmi and 360° scenario contains the basic 42-aircraft as part of the total target count. These 42 targets were overlayed to provide a subset that was analyzed and from which statistics were gathered. The remaining 358 targets were randomly generated at altitudes from 10,000 to 30,500 feet, at velocities of 100 to 500 knots, and headings from 0° to 360°. Whenever a random target reached the 60-nmi range, it executed a 180° turn and flew in the opposite direction. The total count of the random targets was evenly distributed between DABS and ATCRBS.

APPENDIX B

COMMUNICATIONS TEST MESSAGE

1. Tactical Uplink Message (Type Code 21). The sensor delivers the uplink to the aircraft and responds (to the ATC facility via the outgoing comm buffer) with a message delivery notice (Type Code 32). If the aircraft is not in the scenario at the time the message is to be sent, the sensor sends a message rejection notice (Type Code 31) to the ATC facility.

2. Request for Downlink (Type Code 23). The sensor sets the run length (RL) bit in the next interrogation to the aircraft and ARIES replies with a Comm B message sent to the ATC facility as a tactical downlink (Type Code 41).

3. ATCRBS ID Request (Type Code 24). The sensor sets the altitude/identity designator (AI) bit in the next interrogation to the aircraft and ARIES sends the ATCRBS ID in the next reply. An ATCRBS ID message (Type Code 45) is sent to the ATC.

4. Data Link Capability Request (Type Code 02). The sensor responds with a data link capability message (Type Code 44), with the capability information for the aircraft obtained from the surveillance file.

5. Pilot-initiated Comm B (Simulated by ARIES Setting the B-bit in a Surveillance Reply for a Specific Aircraft). The sensor sends (on the same scan) an interrogation with the RL bit set to request the downlink, and ARIES replies with a Comm B reply with the B-bit set. The Comm B is sent to the ATC facility as a tactical downlink.

NOTE: N40 (727) for high altitude flights (depending on availability)
N47, N48, N40 for medium altitude flights (depending on availability)
N50 for low altitude flights (depending on availability)

NOTE: Deviations from above plans may be necessary due to ATC coordination, aircraft availability, etc.

NOTE: Maximum range flights at 26,000 feet are about 65 nmi from the terminal sites and about 200 nmi from the en route sites.